Indiana Bat and Northern Long-Eared Bat

Final Habitat Conservation Plan

for the Headwaters Wind Farm

Randolph County, Indiana

Prepared by:

Headwaters Wind Farm LLC
a subsidiary of EDP Renewables North America LLC

In consultation with:
Western EcoSystems Technology, Inc.

April 2019

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Overview and Background

The Headwaters Wind Farm (Project) consists of 100 wind turbines with a total generating capacity of approximately 200 megawatts (MW). The Project is located on private land in Randolph County in east central Indiana (Figure 1.1) and is owned by Headwaters Wind Farm LLC (Applicant), a Delaware limited liability company, which is a subsidiary of EDP Renewables North America LLC (EDPR), a Delaware limited liability company. The Applicant has prepared this Habitat Conservation Plan (HCP) in order to apply for an Incidental Take Permit (ITP or permit) under § 10(a)(1)(B) of the Endangered Species Act, 16 United States Code [USC] Section (§) 1531-1599 (1973), 1539(a)(1)(B), (ESA).

1.1.1 *Purpose and Need*

During Project development and early coordination with the US Fish and Wildlife Service (USFWS or Service), the Applicant determined that the Project could pose a risk to Indiana bats (*Myotis* sodalis), a species listed as endangered under the ESA. When northern long-eared bats (*M. septentrionalis*) became listed as a threatened species under the ESA later in the Project development process, the Applicant determined that this species may also be at risk from operation of the Project. Based on these determinations, the Applicant decided to prepare this HCP in support of an ITP application.

The implementing regulations for § 10(a)(1)(B) of the ESA (50 Code of Federal Regulations [CFR] 17.22) identify the criteria by which a permit allowing the incidental take of endangered species and threatened species listed under the ESA (listed species) may be obtained. The purpose and need for the ITP is to ensure that incidental take resulting from the operation of the Project and mitigation measures prescribed in this HCP (Covered Activities) will not appreciably reduce the likelihood of the survival and recovery of the Indiana bat and northern long-eared bat (Covered Species) in the wild.

The ITP application must be accompanied by an HCP. An HCP must describe the estimated impacts of take of the Covered Species for which authorization is sought and how those impacts will be minimized and mitigated to the maximum extent practicable. In addition, an HCP must describe monitoring that will be implemented to ensure compliance with the ITP, and the funding mechanism that will be used to implement monitoring, mitigation, and responses to any changed circumstances. This HCP includes these and other elements necessary to meet the criteria for ITP issuance (see Section 1.2.1 for a list of all required issuance criteria).

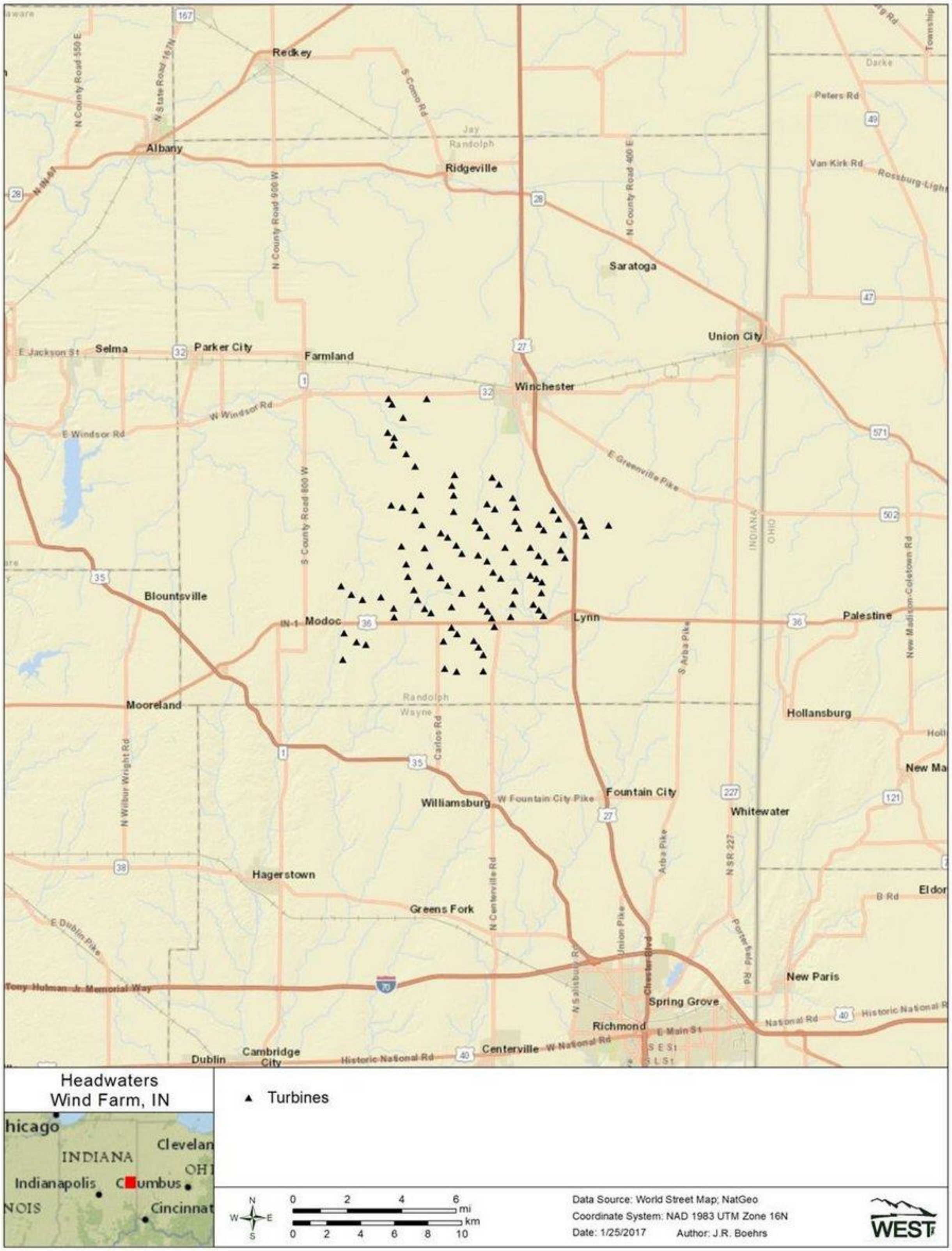

Figure 1.1 Location of the Headwaters Wind Farm.

1.1.2 Organization

The HCP is divided into nine chapters according to the preceding table of contents and following the 2016 revised USFWS and National Marine Fisheries Service (NMFS) *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook). This chapter describes the overview of the HCP, the regulatory framework, the duration of the requested ITP, and the Covered Lands and Covered Species. Chapter 2 of this HCP provides a description of the Project and the activities for which incidental take coverage is sought. Chapter 3 provides a description of the Covered Species' biology. Chapter 4 provides a detailed analysis of the take of the Covered Species that is likely to result from Covered Activities and the impact of that taking on the species. Chapter 5 describes the measures the Applicant will implement to minimize and mitigate the impacts of the take to the maximum extent practicable. Chapter 6 describes the funding assurances that the Applicant will provide to ensure implementation of the HCP. Chapter 7 addresses the alternatives to the taking that the Applicant considered, but did not elect to implement. Chapter 8 describes the timing and details of plan implementation, including changed and unforeseen circumstances that could arise over the ITP term and procedures the Applicant will utilize to address changed circumstances. Chapter 9 provides references for the sources of data and information used in the development of the HCP, as well as a list of acronyms and abbreviations. In addition to the chapters as described, the HCP includes a number of appendices with supporting information.

1.2 Statutory and Regulatory Framework

1.2.1 Endangered Species Act

The purpose of the ESA is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved…" (ESA § 2(b), 16 USC 1531(b)). The ESA § 9(a)(1)(B) prohibits the take of any species of fish or wildlife listed under the ESA as an endangered species (16 USC 1538(a)(1)(B)). The USFWS extended by regulation the "take" prohibition to fish and wildlife species listed under the ESA as threatened species, unless the USFWS promulgates a special species-specific rule for a threatened species that applies the "take" prohibition in full or in part to that species (50 CFR 17.31(a)). Under the ESA, the term "take" means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA § 3(19), 16 USC 1532(19)).

The ESA § 10(a)(1)(B) provides that the Secretary of the Interior (Secretary) and the Secretary of Commerce may authorize, under certain terms and conditions, any taking otherwise prohibited by the ESA § 9(a)(1)(B) if such taking is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (16 USC 1539(a)(1)(B)). To obtain this incidental take authorization, a non-federal landowner, land manager, or Project proponent must apply to the USFWS or NMFS for an ITP, and develop, fund, and implement a USFWS- or NMFS-approved HCP to minimize and mitigate to the maximum extent practicable the impact of the proposed taking[1].

As outlined in the ESA § 10(a)(2)(A) (16 USC 1539(a)(2)(A)) and its implementing regulations at 50 CFR §§ 17.22(b)(1) and 17.32(b)(1), to obtain an ITP the applicant must submit:

1) A complete description of the activity sought to be authorized;
2) The common and scientific names of the species sought to be covered by the permit, as well as the number, age, and sex of such species, if known;
3) A conservation plan that specifies:
    a. The impact that will likely result from such taking;
    b. What steps the applicant will take to monitor, minimize, and mitigate such impact, the funding that will be available to implement such steps, and the procedures to be used to deal with unforeseen circumstances;
    c. What alternative actions to such taking the applicant considered and the reasons why such alternatives are not proposed to be utilized; and
    d. Such other measures that the Secretary may require as being necessary or appropriate for purposes of the plan.

An ITP will be issued if, after a specified public comment period, the USFWS finds that the ITP application and the related HCP meet the following *issuance criteria* outlined in the ESA § 10(a)(2)(B) and 50 CFR §§ 17.22((b)(2) and 17.32 (b)(2):

1) The taking will be incidental;
2) The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;
3) The applicant will ensure that adequate funding for the HCP and procedures to deal with unforeseen circumstances will be provided;
4) The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild;
5) Any other measures that the USFWS may require as being necessary or appropriate will be met; and
6) USFWS has received such other assurances as the USFWS may require that the plan will be implemented.

[1] As the species covered by this HCP are within the jurisdiction of the Secretary of the Interior and the USFWS, hereafter all references to "Secretary" refer to the Secretary of the Interior and no references will be made to the NMFS.

In addition to these necessary HCP elements, the HCP Handbook (USFWS and NMFS 2016) describes five clarifying components that should be included in an HCP:

1) Biological goals and objectives,
2) Adaptive management,
3) Monitoring,
4) ITP duration, and
5) Public participation.

The issuance of the ITP is a federal agency action that must also comply with § 7 of the ESA (16 USC 1536). The ESA § 7 requires federal agencies to consult with the USFWS to ensure that actions that the federal agencies implement, authorize, or fund are not likely to jeopardize the continued existence of any listed species or result in destruction or adverse modification of designated critical habitat of such species. Under the authority of ESA § 7 and implementing regulations, where, as here, the federal agency action is the USFWS's issuance of an ITP under ESA § 10, the USFWS must conduct an internal formal consultation process for issuance of the ITP. Formal consultation terminates with preparation of a Biological Opinion (BO), which provides the Service's determination as to whether the proposed action of ITP issuance is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. This intra-Service consultation ensures that issuance of the ITP meets the ESA § 7 standards.

1.2.2 National Environmental Policy Act

The National Environmental Policy Act, 42 USC § 4321, *et. seq.* (NEPA) requires federal agencies to examine environmental impacts of their actions and provide for public participation. Issuance of an ITP is a federal action subject to compliance with NEPA. To comply with NEPA, the USFWS must conduct and publish an environmental impact statement or environmental assessment that includes detailed analysis of all direct, indirect, and cumulative impacts to the human environment resulting from issuance of the ITP

1.3 Permit Duration

The proposed term of the requested ITP for the Project is 27 years. This 27-year ITP term provides for a minimum 30-year functional operational life of all turbines, with the start of Project operation in December 2014 and an anticipated ITP start date of fall 2018. If, at the end of the 27-year term of the requested ITP, the Applicant decides to continue to operate the Project, the Applicant will apply for a new ITP or for an ITP renewal. This continued operation of the Project (re-powering) is considered a foreseeable changed circumstance and is addressed further in Chapter 8.

1.4 Covered Lands

The lands covered by this HCP include the Plan Area and the Permit Area. The Plan Area is the geographic area that is analyzed in the NEPA analysis and the ESA §7 intra-USFWS consultation. It includes any and all areas that may be within the HCP's sphere of influence, whether or not take is likely to occur. The Applicant has determined that the Plan Area for the HCP includes the Permit Area (Figure 1.2), as well as all areas influenced by the HCP's biological goals and objectives, such as the minimization, monitoring, and adaptive management measures associated with this HCP (see Section 5). As such, the Plan Area includes the Permit Area and all lands involved in the off-site mitigation project(s) associated with this HCP (see Section 5.3).

The Applicant proposes to offset the impact of the taking under this HCP by securing and protecting habitat to support critical stages of the Covered Species' life history (see Section 5.3). Components of the mitigation include an Indiana bat hibernaculum (Wind Cave) in Kentucky and protection of a yet-to-be-identified parcel that provides summer habitat for Indiana bats and northern long-eared bats, as well as swarming habitat for Indiana bats. The Wind Cave mitigation site is described in greater detail in Appendix A.

The Permit Area is a subset of the Plan Area and consists of all areas under the Applicant's control where take of the Covered Species is expected to occur and be authorized by the requested ITP. Operation of Project wind turbines is the only activity that is likely to cause take of the Covered Species; therefore, the Permit Area includes the area in which all 100 turbines will be located (Figure 1.2). In addition, the Permit Area includes all easements, fee lands, and land leased for other facilities associated with the Project, such as the underground collection system, substation/switchyard, operations and maintenance facilities, permanent meteorological (met) towers, access roads, generator lead line, and collection and distribution line easements.

The total area under lease for the Project covers approximately 21,775 ha (53,808 ac) and is owned by approximately 180 private landowners. The predominant landcover/vegetation type within the Permit Area is agricultural, primarily corn (*Zea mays*) and soybean (*Gylcine max*) fields. All areas temporarily disturbed by construction and all areas above underground facilities (e.g., collector lines) were restored to the agricultural vegetation type after construction.

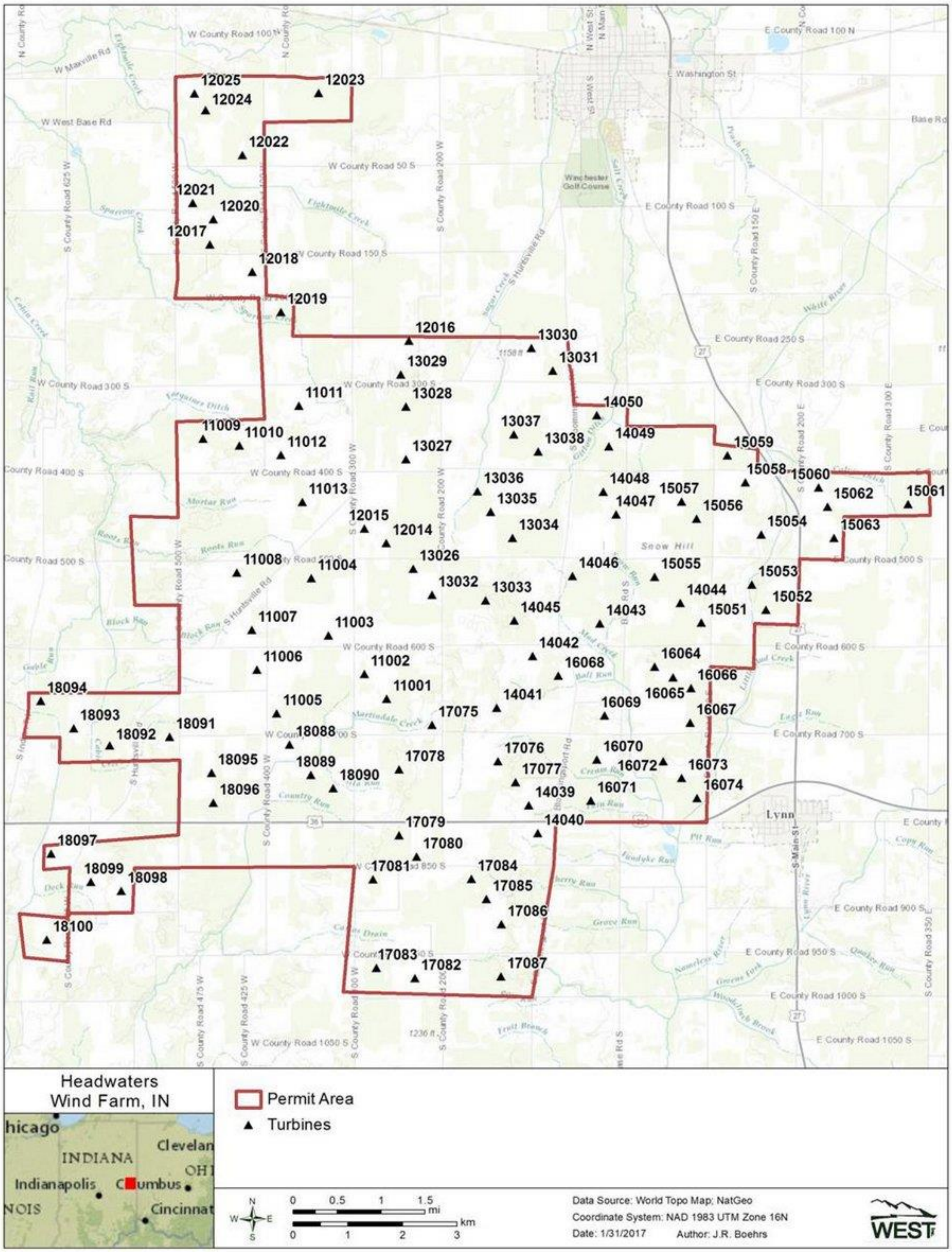

Figure 1.2 Permit Area for the Headwaters Wind Farm Habitat Conservation Plan.

1.5 Covered Species

The Applicant is applying for an ITP for the Indiana bat and the northern long-eared bat for the Covered Activities as described below. The Indiana bat is listed as an endangered species under the ESA (see USFWS 1967) and the northern long-eared bat is listed as a threatened species under the ESA (80 Federal Register [FR] 17974; USFWS 2013c, 2015b). No land within the Permit Area is designated as critical habitat under the ESA.

Currently, no other endangered species, threatened species, or candidate species under the ESA are known to occur in the Permit Area, and no critical habitat designated under the ESA is located within the Permit Area. The potential future listing of additional species that could be adversely affected by the Project is considered a changed circumstance and is addressed further in Chapter 8 of this HCP.

2.0 PROJECT DESCRIPTION AND COVERED ACTIVITIES

2.1 Project Description

The Project consists of 100 wind turbines and associated facilities and has a total generating capacity of approximately 200 MW. The Project is located on private land in east-central Indiana in Randolph County. Commercial operation of the Project began in December 2014.

2.1.1 Project Components

The Project components include the following:

- Wind turbines;
- Met towers;
- Roads and pads;
- Generator lead line;
- Underground collection and communications cables;
- Substation and switchyard; and
- Operations and maintenance (O&M) facilities.

2.1.1.1 <u>Wind Turbines</u>

The Project consists of 100 Vestas V110 2.0-MW turbines. The turbine towers are approximately 95 meters (m; 312 feet [ft]) in height and the rotor blade diameter is 110 m (361 ft). Therefore, the maximum height of the turbines from tower base to highest blade tip is 150 m (492 ft) above ground level.

2.1.1.2 Meteorological Towers

Three permanent un-guyed 95 m (312 ft) met towers are located within the Permit Area. All temporary met towers associated with the Project were decommissioned at the time of Project construction. The permanent met towers and associated electrical components are situated on an approximately 12.8 x 12.8-m (42.0 x 42.0-ft) gravel pad and within an approximately 12.2 x 12.2-m (40.0 x 40.0-ft) chain link fenced area accessible to Project access roads via a 3.7-m (12.0-ft) access road.

2.1.1.3 Roads and Pads

Roads associated with the Project include upgraded existing roads and new roads, both of which were constructed in accordance with industry standards for wind facility roads and local building requirements. The roads accommodated all-weather access by heavy equipment during construction and continue to accommodate long-term use during O&M.

All new roads were constructed for the specific purpose of Project construction, operation, and maintenance. The permanent width of access roads is approximately 5 m (16 ft). All roads include road base, surface materials, appropriate drainage, and culverts where necessary.

The crane pad at each turbine site consists of an approximately 20 x 40-m (65 x 131-ft) permanent gravel pad extending from the roadway to the turbine foundation.

2.1.1.4 Underground Electrical and Communications Cables

Electrical power generated by the wind turbines is transformed and collected through a network of underground collection cables. The underground collection cables total approximately 139 kilometers (km; 86.5 miles [mi]) in length. Communications cables were also buried underground with the collection cables in approximately 1.2-m (4.0-ft) deep trenches located between turbines and along access roads.

2.1.1.5 Generator Lead Line

The 16-km (10-mi) generator lead line is owned by the Applicant and consists of approximately 47 poles spaced approximately 365 m (1,200 ft) apart.

2.1.1.6 Substation and Switchyard

The substation is connected to the interconnection point, an existing 345-kilovolt electrical line, by the new generator lead line. The substation consists of transformation and switching equipment to collect the energy from the Project to make suitable for delivery into the bulk power system. The interconnect switchyard is an electrical station with switching and protection equipment that acts as a hub between the bulk power system and the Project.

2.1.1.7 Operations and Maintenance Facility

The O&M facility consists of an approximately 658 square m (m^2; 7,080 ft^2) building containing office space, storage space, bathrooms, and a kitchenette.

2.1.2 Operations and Maintenance

The Project is operating both locally from the control room in the O&M building and remotely from Houston, Texas, through a remote operations control center. A permanent staff of 12 to 15 on-site personnel provides O&M support activities to the Project. Each turbine includes a supervisory control and data acquisition (SCADA) operations and communications system that allows automated independent and remote operation of the turbine. The SCADA data provide detailed operating and performance information for each turbine, allowing real-time control and continuous monitoring to ensure optimal operation and identification of potential problems. A local wind technician is either on-site or available on-call to respond in the event of emergency notification or critical outage.

A preventative maintenance and inspection schedule has been implemented for the Project. Typical O&M activities include wind turbine inspections and maintenance activities on wind turbines, as required. Some repair activities may require the use of heavy equipment, such as cranes, to assist in the repairs of components such as the rotor, turbine blades, and nacelle components.

Maintenance activities include periodic mowing to increase searcher efficiency during mortality monitoring (see Section 5.4.1) and to retain previously-cleared areas associated with Project infrastructure (roads, generator lead line) and rights-of-way (ROWs). Mowing maintains cleared areas in an herbaceous or shrub-scrub condition. The need for mowing is evaluated by site operations staff periodically during the growing season and the mowing occurs on an as-needed basis during daytime hours. Maintenance also consists of building inspection and repairs, as needed; periodic grading of roads to restore the road surface or repair of culverts, as needed; and annual inspection and removal of hazards (e.g., downed trees or encroaching branches) on the generator lead line.

Required Federal Aviation Administration (FAA) lighting (see FAA 2000, 2007) has been installed on the nacelles of selected wind turbines. The O&M facility has outside safety lights that may be operated manually or via motion detectors. Additionally, the O&M facility has exterior lighting on the building, as well as the parking lot, that are operated by dusk-to-dawn sensors.

Despite the potential for Indiana bats to roost in the northern portion of the Permit Area and the potential for northern long-eared bats to roost in the western portion of the Permit Area (see Section 3.4), maintenance (e.g., turbine maintenance, road grading, maintenance facility upkeep, SCADA upgrades, and grounds keeping) activities are not expected to lead to impacts that rise to the level of take. Maintenance of the turbines involves periodic activities typically conducted inside turbines or the O&M building; occasionally maintenance activities may require the use of a crane to access the rotors or nacelles. These types of activities do not present hazards to the Covered Species because they do not generate excessive noise or activity that could lead to disturbance of Indiana bats or northern long-eared bats potentially roosting within the Permit Area. Additionally, during all seasons, maintenance activities would be conducted primarily during daylight hours when the Covered Species are not active.

Any emergency tree removal[2] for Project maintenance will be conducted as needed. If removal of high risk hazard trees is necessary from April 1 – October 15, the Applicant will notify the USFWS in advance and, if appropriate, have a qualified biologist conduct an emergence survey at the tree(s) requiring removal. If no bats[3] are observed during the emergence survey, the high risk hazard tree(s) will be promptly removed. This will reduce the risk of removing a potential roost tree. If bats are observed, the Applicant will conduct further consultation with the USFWS. Therefore, maintenance activities are not expected to result in impacts that could rise to the level of take.

2.1.3 Decommissioning

The projected operating life of the Project is 25 years. After the useful life of the turbines is complete, the Applicant will assess the viability of either repowering the Project by installing new or refurbished turbines or completely decommissioning the Project. In the event that the Project will be decommissioned after 25 years, the decommissioning process will be similar in scope and duration to the construction process. Most components and materials will be removed, recycled, or disposed of in approved and appropriate waste management facilities. Decommissioning activities would occur during daylight hours and would not create hazards for active bats, including the Covered Species. Turbines would be locked to prevent spinning during decommissioning, which would avoid the potential for collision of Covered Species with spinning turbines.

Similar to maintenance activities, any tree removal necessary for decommissioning is expected to be conducted during the winter months (October 16 – March 31) to avoid potential take of the Covered Species. If tree clearing is necessary during the Covered Species' active period, the same procedures will be followed as described above for maintenance activities. Decommissioning of the Project is not expected to cause take of the Covered Species and is therefore not a requested Covered Activity under the requested ITP.

2.1.3.1 <u>Decommissioning Process</u>

The decommissioning process, which should be completed within 18 months, includes removal of above-ground structures, concrete foundations to a depth of at least 1.2 m below the surface, removal of access roads if required by the landowner, restoration of topsoil, and re-vegetation and seeding. Turbine blades will be "feathered"[4], locked, and de-powered.

---

[2] Emergency tree removal would be for trees that pose an imminent risk of human life or property damage.

[3] This refers to bats of any species. If the hazard tree has the potential to be a roost tree for one of the Covered Species based on tree species, bark condition, size, and exposure, it will be assumed that emerging bats could potentially be the Covered Species.

[4] The feathered position is when turbine blades are pitched parallel with the wind direction, causing them to spin only at very low rotation rates (maximum one to two rotations per minute), if at all.

Above-ground structures include the turbines, transformers, substation, maintenance building, met towers, generator lead line, and communications equipment. Below-ground structures include turbine foundations, collection and communication system, drainage structures, and access road sub-base material. The process of removing structures involves evaluating components and materials for reuse, salvage, recycling, and/or disposal. Components and materials may be stored on-site until ready for transport. The components and materials will be transported to appropriate facilities for reconditioning, salvage, recycling, or disposal.

Access roads will be widened as necessary to accommodate movement of cranes or other machinery required for the disassembly and removal of the turbines. Road widening will be minimized to the greatest extent practicable and any tree removal necessary will be conducted during the winter months (October 16 – March 31) to avoid any potential take of the Covered Species. Turbine components, control cabinets, electronic systems, and internal cables will be de-energized and removed. The blades, hub and nacelle will be lowered to the ground for disassembly. The tower sections will be disconnected and lowered to the ground where they will be further disassembled as needed into transportable sections.

Foundations (e.g., of turbines, transformers, met towers) will be excavated to remove anchor bolts, rebar, conduits, cable, and concrete to a depth of 1.2 m below grade. The excavations will be filled and compacted with clean sub-grade material of a quality and density comparable to the surrounding area. All unexcavated areas compacted by equipment used in decommissioning will be de-compacted to adequately restore the topsoil and sub-grade material to the proper quality and density comparable to the surrounding area.

The collector and communications cables and conduits will be cut back to a depth no greater than 1.2 m below grade. All cable and conduit buried greater than 1.2 m below grade will be left in place and abandoned. Decommissioning of the substation will include removal of fencing, conductors, switches, transformers, foundations, and other substation components. Substation material and equipment disposal, reconditioning, or reuse will be dependent on condition and market value. Foundations and underground components will be removed to a depth of 1.2 m below grade and the excavation filled, contoured, and re-vegetated. The O&M building, as a functional and relatively new building in the town of Winchester, would be repurposed upon Project decommissioning.

After decommissioning of the turbines is completed, access roads and construction pads will be removed, unless landowners request that particular access roads remain in place. Gravel will be removed from access roads and turbine pads and transported to a disposal location or approved stockpile site. Drainage structures integrated with the access roads will be removed and backfilled with sub-grade material, the topsoil replaced, and the surface contoured and re-vegetated. At the request of Randolph County, some improvements to local and county roads were not removed after construction and will remain in place.

2.1.3.2 Site Restoration

As part of the decommissioning process, areas requiring restoration or reclamation will be leveled or re-contoured to match the surrounding area, covered with topsoil, and re-seeded, if needed. Other steps taken to prevent soil erosion, ensure establishment of vegetation cover, and/or control for noxious weeds and pests will be conducted as necessary during the decommissioning process.

2.2 Covered Activities

According to the HCP Handbook (USFWS and NMFS 2016), covered activities are "activities that a permittee will conduct for which take is authorized in an ESA § 10 permit." To be eligible for incidental take authorization, covered activities must be "(1) otherwise lawful, (2) non-Federal, and (3) under direct control of the permittee." The HCP Handbook explains that:

> "In addition to having legal authority to carry out the proposed project, the applicant must also have direct control over any other parties who will implement any portion of the proposed activity and the HCP (see 50 CFR 13.25; 50 CFR 222.305(b)). "Direct control" under this regulation extends to:
>
> 1. those who are employed by a permittee (e.g., contractors),
> 2. anyone under the regulatory jurisdiction of a permittee (e.g., the permittee is in a county that issues building permits to individuals with conditions to implement the terms of the HCP), or
> 3. entities have an interagency agreement establishing the permittee's legal control […]." (USFWS and NMFS 2016).

As discussed below, the Applicant has determined which Project-related activities could potentially result in incidental take of the Covered Species, that are reasonably certain to occur, and over which the Applicant has control. Therefore, the Applicant is requesting the operation of 100 turbines over the 27-year ITP term be considered a Covered Activity under the HCP. The Applicant will implement measures to minimize and mitigate potential take that may occur as a result of Project operations. No incidental take of the Covered Species is anticipated from the proposed mitigation project(s); however, the authority granted in the ITP includes implementation of mitigation measures in occupied habitat for the Covered Species, and therefore the Applicant proposes inclusion of these activities as a Covered Activity in the requested ITP.

2.2.1 Operation of the Project

Commercial operation of the Project began in December 2014. The Applicant anticipates that the Project will operate for a minimum of 30 years. Spinning rotor blades[5] are known to cause

[5] Bat deaths and injuries were once thought to also result from decompression sickness, or barotrauma, which was hypothesized to occur in bats flying in close proximity to rotating turbine blades, where it was thought they experienced rapid or excessive pressure change, resulting in pulmonary trauma, or lung damage, due to expansion

injury and mortality of bats through collision (Horn et al. 2008), including mortality and injury of the Covered Species. Due to the potential mortality of the Covered Species from operation of the Project, operation of the 100-turbine Project is included as a Covered Activity in this HCP.

2.2.2 Mitigation Measures

Implementation of this HCP will include measures to mitigate the impacts of the take to the maximum extent practicable. These measures are described in detail in Chapter 5 of this HCP. The mitigation measures are intended to provide conservation benefits to the Covered Species, and thus are not likely to lead to take. However, the authority to be granted in the requested ITP includes implementation of mitigation measures, and therefore these measures, as described in Chapter 5, are included as a Covered Activity in this HCP.

3.0 AFFECTED SPECIES, ENVIRONMENTAL SETTING, AND BASELINE

3.1 Environmental Setting

The Project is located in east-central Indiana and falls within the Eastern Corn Belt Plains Ecoregion, which encompasses a large portion of central and southeastern Indiana and central and southwestern Ohio (US Environmental Protection Agency 2017). The Eastern Corn Belt Plains Ecoregion is primarily a rolling glacial till plain with local end moraines. The Ecoregion is characterized by flat to gently undulating topography. The Permit Area is flat to gently rolling with no ridges or other areas of starkly elevated topography. Elevations within the Permit Area range from approximately 340-370 m (1,100-1,200 ft).

The Permit Area encompasses approximately 11,846 ha (29,272 ac) in south-central Randolph County. According to the 2011 National Land Cover Database (NLCD; US Geological Survey [USGS] NLCD 2011, Homer et al. 2015), the dominant cover type within the Permit Area is cultivated cropland (mainly corn and soybeans) composing 87% of the total land area (Table 3.1, Figure 3.1). Developed open space and deciduous forest are the second most abundant cover types, each composing 5% of the Permit Area. Deciduous forest in the Permit Area mainly occurs as scattered, small woodlots, riparian corridors, and shelterbelts along the edges of agricultural fields and residences. Hay/pasture composes 2% of the Permit Area, while the other land covers (herbaceous, developed low intensity, open water, emergent herbaceous wetlands, evergreen forest, and shrub/scrub) each compose less than 1.0% of the total Permit Area. Developed areas are generally confined to residences and farms scattered throughout the Permit Area. Water sources in the Permit Area include tributaries of the White River in the north and tributaries of the Whitewater River in the south. There are also several unnamed streams and a few farm ponds in the Permit Area.

---

of air in the lungs that was not accommodated by exhalation (Baerwald et al. 2008). However, a recent National Renewable Energy Laboratory (2012) study found that the pressure changes around operating wind turbine blades were not large enough to cause fatal barotrauma in bats.

Table 3.1 Land cover types in the Headwaters Wind Farm according to the 2011 National Land Cover Database.

Land Cover	Hectares	Acres	% Composition
Cultivated Crops	10,258.3	25,348.8	86.6
Developed, Open Space	627.6	1,550.8	5.3
Deciduous Forest	597.6	1,476.7	5.0
Hay/Pasture	288.4	712.6	2.4
Herbaceous	48.6	120.1	0.4
Developed, Low Intensity	16.5	40.8	0.1
Open Water	5.4	13.3	<0.1
Emergent Herbaceous Wetlands	1.2	3.0	<0.1
Evergreen Forest	1.1	2.7	<0.1
Shrub/Scrub	1.1	2.6	<0.1
Total	**11,845.78**	**29,271.6**	**100**

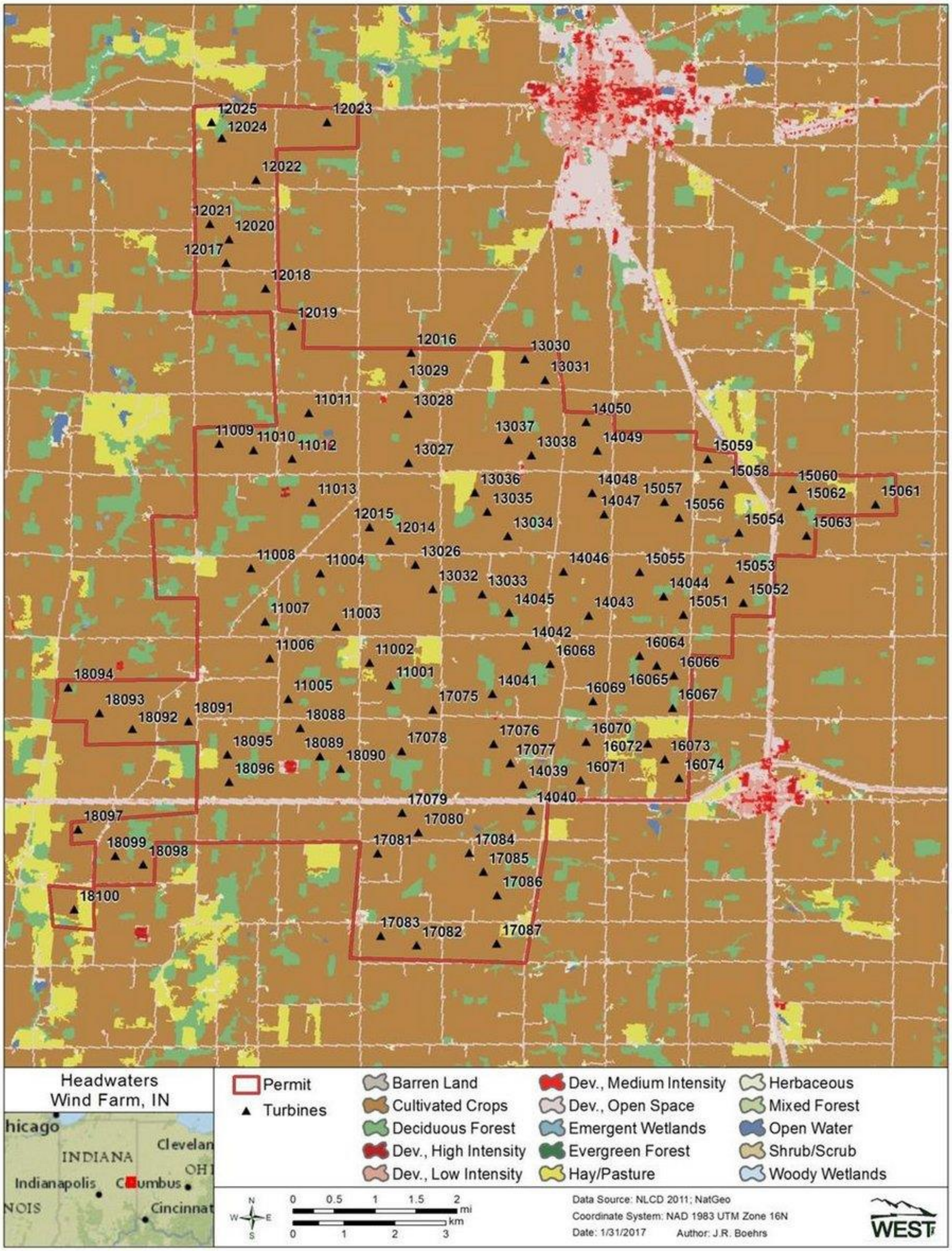

Figure 3.1 Landcover within the Headwaters Wind Farm Permit Area.

3.2 Covered Species – Indiana Bat

The Indiana bat is a small (7.0 to 10.0 gram (g; 0.2 to 0.4 ounce [oz]) insectivorous bat first described as a separate species in 1928 (Miller and Allen 1928) based on museum specimens collected in 1904 from Wyandotte Cave in Crawford County, Indiana. Before that time, specimens of the Indiana bat were confused with those of other *Myotis* species, especially the little brown bat (*M. lucifugus*). The Indiana bat can be distinguished from other *Myotis* species by its smaller foot (0.31 inch [8.0 millimeters (mm)] instead of 0.35 to 0.39 inch [9.0 mm to 10.0 mm] in the little brown bat); short, inconspicuous toe hairs; keeled calcar; more uniformly colored fur; and its pinkish colored pug-nose (Whitaker and Hamilton 1998).

3.2.1 Life History and Characteristics

Indiana bats exhibit life history traits similar to other temperate bat species. Despite the Indiana bat's small size, it is relatively long-lived (Barclay and Harder 2005). Similar to most temperate *Myotis* species, female Indiana bats give birth to one offspring per year (Humphrey et al. 1977, Kurta and Rice 2002). Mating occurs in the vicinity of the hibernacula in late summer and early fall during what is termed the swarming period, and fertilization is delayed until the spring (Guthrie 1933).

Timings of parturition (birth) and lactation are likely dependent in part on latitude and weather conditions. For example, in Iowa, female Indiana bats arrive at maternity colonies at the end of April and parturition is completed by mid-July (Clark et al. 1987); in Michigan, young are born in late June or early July (Kurta and Rice 2002); and in southern Indiana, pregnant females have been documented from May 28 through June 30, while lactation has been recorded from June 10 to July 29 (Whitaker and Brack 2002). Young Indiana bats are volant within three to five weeks of birth, at which time the maternity colony begins to disperse.

Female and juvenile Indiana bats may remain in the maternity colony area until migration to hibernacula. It is likely that once the young are born, females leave their pups in the diurnal roost while they forage, returning during the night periodically to feed them (Barclay and Kurta 2007). Females will, however, switch roost trees regularly and during these switches they must carry flightless young. Indiana bat maternity colonies will use several roosts; in Missouri each maternity colony used between 10 and 20 separate roost trees (Miller et al. 2002). In Kentucky, Gumbert et al. (2002) recorded 463 roost switches over 921 radio-tracking days of tagged Indiana bats (predominantly males): an average of one switch every 2.21 days. Consecutive use of roost trees by individual Indiana bats ranged from one to 12 days. There are a number of suggested reasons for roost switching, including thermoregulation, predator avoidance, and reduced suitability of a roost tree (an ephemeral resource that may become unusable if it is toppled by wind, loses large pieces of bark, or is otherwise destroyed; Kurta et al. 2002, Barclay and Kurta 2007).

Indiana bats return to the vicinities of hibernacula in late summer and early fall where Indiana bats exhibit a behavior known as "swarming". This involves large numbers of Indiana bats flying in and out of the cave entrances from dusk to dawn, though relatively few of the Indiana bats roost in the cave during the day (Cope and Humphrey 1977). During the swarming period, most Indiana bats roost within approximately 2.4 km (1.5 mi) of the cave, suggesting that the forests around the caves provide important habitat prior to hibernation (USFWS 2007a). It is at this time that Indiana bats gain fat stores vital not only for winter survival, but also for when mating occurs during swarming.

While females enter the hibernaculum soon after arrival at the site, males remain active for a longer period and may also travel between hibernacula, both behaviors that may increase mating opportunities (USFWS 2007a). Spring emergence from the hibernacula generally occurs from mid-April to the end of May and varies across the range, depending on latitude and weather conditions. Females typically emerge before males, traveling sometimes hundreds of miles to summer habitats after emergence (Winhold and Kurta 2006).

3.2.2 Habitat Requirements

Indiana bats have two distinct habitat requirements: 1) a stable environment in which to hibernate during the winter, and 2) woodland habitat in which to roost during the summer (USFWS 2007a). These and other, less clearly-defined habitat associations during different periods of the Indiana bat life cycle will be described in the following sections.

3.2.2.1 Winter Habitat

Indiana bats generally hibernate from October to April, although this may be extended from September to May in northern parts of their range (USFWS 2007a). The majority of hibernacula are located in karst areas of the east-central US. Indiana bats are also known to hibernate in other cave-like structures. For example, Indiana bats have been found hibernating in man-made tunnels in Pennsylvania (Sanders and Chenger 2000, Butchkoski and Turner 2008), and, in 1993, an Indiana bat was discovered hibernating in a hydroelectric dam in Manistee County, Michigan, 450 km (281 mi) from the closest recorded hibernaculum for Indiana bats in LaSalle County, Illinois (Kurta and Teramino 1994). In 2005, approximately 30% of the population hibernated in man-made structures (predominantly mines), with the rest using natural caves (USFWS 2007a).

Indiana bats typically require low, stable temperatures (3 degrees [°] to 8° Celsius [C; 37° to 46° Fahrenheit (F)]) for successful hibernation (Tuttle and Kennedy 2002, Brack 2004). Cave configuration determines internal microclimate, with larger, more complex cave systems with multiple entrances more likely to provide suitable habitat for the Indiana bat (Tuttle and Stevenson 1978, LaVal and LaVal 1980, Richter et al. 1993). Most Indiana bats hibernate in caves or mines that tend to have large volumes, large rooms, and extensive vertical relief and passages that are often below the lowest entrance. Cave volume and complexity help buffer the cave environment against rapid and extreme shifts in outside temperature, and vertical relief provides a range of temperatures and roost sites (USFWS 2007a). Indiana bats are also able to decrease exposure to fluctuating air temperatures by increasing surface contact with the cave or other individuals. As such, Indiana bats tend to hibernate in large, dense clusters, ranging from 3,333 to 5,555 bats per m^2 (300 to 500 bats per ft^2; USFWS 2007a, Boyles et al. 2008). It is suggested that in hibernacula with small populations, Indiana bats cluster with other bat species (such as little brown bats) to gain this thermoregulatory advantage (USFWS 2007a).

A key component to the survival and recovery of the Indiana bat is maintenance of suitable hibernacula that ensure the over-winter survival of sufficient individuals to maintain population viability. The *Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision* (2007 Draft Indiana Bat Recovery Plan) categorizes hibernacula into four groups based on the priority to the species population and distribution. The Priority 1 (P1) hibernacula are essential to the recovery and long-term conservation of the species and have a current or historically observed winter population of 10,000 or more Indiana bats. The Priority 2 (P2) hibernacula contribute to the recovery and long-term conservation of the species and have a current or historical population of more than 1,000 but less than 10,000 Indiana bats. The Priority 3 (P3) sites have a current or historical population of 50-1,000 Indiana bats, and Priority 4 (P4) sites have a current or historical population of less than 50 Indiana bats (USFWS 2007a).

3.2.2.2 Spring Emergence and Dispersal

In the spring, female Indiana bats emerge from hibernacula and disperse to their summer habitat where they form maternity colonies (Winhold and Kurta 2006). Radio-telemetry studies and band return data have shown that dispersal or migration distances vary across the species' range. Individuals radio-tracked in the northeastern U.S. appear to travel the shortest distances (Hicks 2006, USFWS 2007a). Recent radio-telemetry studies of 130 spring-emerging Indiana bats (primarily females) from six New York hibernacula found that approximately 75% of these Indiana bats were later detected, and all of those had migrated less than 68 km (42 mi) to their summer habitat (Butchkoski et al. 2008). Migration distances for Indiana bats in the Appalachian Mountain region appear to be longer than those in the northeast (maximum distance reported for an adult female to date is 173 km [107 mi]; Butchkoski and Turner 2008), but not as long as those in the Midwest. Indiana bats in the Midwest appear to migrate the longest distances between hibernacula and their summer habitat. Twelve female Indiana bats from maternity colonies in Michigan migrated an average of 477 km (296 mi) to their hibernacula in Indiana and Kentucky, with a maximum migration of 575 km (357 mi; Winhold and Kurta 2006), which is the maximum migration distance recorded for the species. Gardner and Cook (2002) also reported long-distance migrations for Indiana bats traveling between summer ranges and hibernacula in the Midwest.

Some non-reproductive female and male Indiana bats do not migrate as far as reproductive females, and instead remain in the vicinity of their hibernacula throughout the summer (Gardner and Cook 2002, Whitaker and Brack 2002). For example, mist-netting studies conducted from 1978 to 2002 mainly near maternity roosts in southern Michigan showed that only about 11% of the adults captured were males (Kurta and Rice 2002). However, some males make longer movements away from hibernacula. Males captured in southern Michigan likely migrated over 400 km (249 mi) from hibernacula in southern Indiana and Kentucky, based on several band return records for Indiana bats captured in this area (Kurta and Murray 2002).

Little is known about behavior of Indiana bats during migration. Indiana bats may try to minimize the time spent in transit, since migration is energetically expensive and dangerous (Fleming and Eby 2003). This may be especially true for reproductive females during the spring when they are pregnant and energetically constrained from spending the winter in hibernation. It appears that Indiana bat migration from winter to summer habitat is fairly linear and short-term, while in the fall, it is more dispersed and varied. Spring radio-telemetry studies have documented migrating Indiana bats traveling in relatively direct flight patterns towards their summer ranges shortly after they emerge from hibernacula (Britzke et al. 2006, Butchkoski and Turner 2006).

Based on a combination of aerial and ground tracking, Indiana bats tracked from a hibernaculum in Pennsylvania flew almost straight lines to their roost trees 135 to 148 km (83 to 92 mi) away in Maryland (Butchkoski and Turner 2005). Similarly, a comparison between the range of initial bearings and the final bearings for 82 reproductive female Indiana bats radio-tracked to 65 maternity colonies in New York from 2000 to 2005 showed that Indiana bats followed more or less direct routes from hibernacula to their summer ranges (Hicks et al. 2005). Evidence from radio-tracking studies in New York and Pennsylvania indicate that Indiana bats are capable of migrating at least 48-64 km (30-40 mi) in one night (Sanders et al. 2001, Hicks 2004, Butchkoski and Turner 2006).

There is some evidence that Indiana bats in the Appalachian Mountain region and Northeast follow landscape features while migrating. Based on observations of 22 Indiana bats tracked during spring telemetry studies in Pennsylvania from 2000 to 2006, Indiana bats appeared to go out of their way to follow tree lines, including riparian buffers along streams through otherwise developed areas, and avoided open areas (Turner 2006). Several Indiana bats tracked during spring migration from the South Penn Tunnel in south-central Pennsylvania appeared to be moving along US Route 220, also known as the Appalachian Throughway, which follows a generally northeast-southwest direction in line with the Appalachian Mountains (J. Chenger, Bat Conservation Management [BCM], personal communication [pers. comm.]). Similarly, 12 Indiana bats tracked during spring migration in western Virginia generally followed ridges that run northeast-southwest, with only one Indiana bat flying east (i.e., into the Shenandoah Valley) and none flying west (i.e., over the higher mountain ridges into West Virginia), suggesting that Indiana bats used ridgeline corridors as migration flyways (McShea and Lessig 2005).

3.2.2.3 <u>Summer Habitat</u>

Suitable summer habitat includes roosting areas, foraging areas, and travel corridors. Suitable summer roosting habitat is characterized by trees (dead, dying, or alive) or snags with exfoliating or defoliating bark, or containing cracks or crevices that can be used as a roost. Foraging habitat includes forested patches, wooded riparian corridors, and natural vegetation adjacent to these habitats. Travel corridors (used for movement between roosts and between roosting and foraging habitat) consist of open corridors in wooded tracts, tree lines, wooded hedgerows, and other pathways that are connected to roosting or foraging areas (USFWS 2007a).

Female Indiana bats predominantly roost under slabs of exfoliating bark, preferring not to use tree cavities, but occasionally using narrow cracks in trees (Kurta 2004). Maternity colonies use primary roosts and alternate roosts. Primary roosts were defined by Callahan (1993) in terms of number of Indiana bats (i.e., roosts used by more than 30 Indiana bats), but they may also be defined by the number of bat-days the roosts are used over one maternity season (Kurta et al. 1996, Callahan et al. 1997, USFWS 2007a). Primary roosts are used throughout the summer, while alternate roosts are used less frequently and may be important during changing weather conditions (temperature and precipitation), or when the primary roost becomes unusable (Callahan et al. 1997).

Due to their cryptic nature, the first Indiana bat maternity colony was not discovered until 1971 (Cope et al. 1974, Gardner and Cook 2002). Maternity colonies vary greatly in size in terms of number of individuals and number of roost trees used, with members of the same colony utilizing over 20 trees during one season (Kurta 2004). Roosts are usually located in dead trees, though partly dead or live trees (e.g., if the tree species has naturally peeling bark) may also be used (USFWS 2007a).

A meta-analysis of 393 roost trees in 11 states found 33 tree species that were used by female Indiana bats and their young, with ash (*Fraxinus* spp.), elm (*Ulmus* spp.), hickory (*Carya* spp.), maple (*Acer* spp.), poplar (*Populus* spp.), and oak (*Quercus* spp.) accounting for approximately 87% of trees documented (Kurta 2004). Roost trees also vary in size. Typically, maternity colony roost trees are greater than 22 centimeters (cm; 8.6 inches) diameter-at-breast-height (dbh; Kurta 2004). The mean size roost tree for a maternity colony (including primary and alternate roosts) in the aforementioned meta-analysis was (mean ± the standard deviation) 45 ± 2.0 cm dbh, range 28 to 62 cm dbh (18 ± 0.8 inches, range 11 to 24 inches; Kurta 2004, Britzke et al. 2006). The smallest maternity roost tree recorded was 11 cm (4.3 inches) dbh (Britzke 2003). Primary roosts can be much larger. For example, the average of five primary roosts used between 1997 and 2001 during long-term studies of the Indiana bat at the Indianapolis International Airport was 65.8 cm dbh (25.9 inches; D. W. Sparks, USFWS, unpublished data).

An important characteristic for the location of maternity roost sites is a mosaic of woodland and open areas, with the majority of maternity colonies having been found in agricultural areas with fragmented forests (USFWS 2007a). Mean values of canopy cover were highly variable among studies (20-88%; USFWS 2007a). Reports of roost trees in closed-canopy forests may appear to conflict with statements that primary roosts are generally located in areas with high solar exposure (e.g., Gardner et al. [1991] reported that 32 of 48 roost trees examined in Illinois occurred within forests with 80% to 100% canopy closure). There are several points to consider in evaluating this apparent discrepancy.

First, some variation undoubtedly was related to differences in methodology, because virtually every study measured canopy cover in a different way. Second, roosts found in closed-canopy forests, particularly primary roosts, were often associated with natural or man-made gaps (e.g., openings created when nearby trees fell, riparian edges, and trail or forest road edges).

Although the forest may be accurately described as closed canopy, the canopy in the immediate vicinity of the roost tree may have had an opening that allowed for solar radiation to reach the roost. Indiana bat roosts have been created by the death of a single large-canopy tree (A. King, USFWS, pers. comm. 2005 as cited in USFWS 2007a). Further, the absolute height of the roost tree appears to be less important than the height of the roost tree relative to the height of surrounding trees, with roost trees often extending above the surrounding canopy (Kurta 2004).

Primary roosts usually receive direct solar radiation for more than half the day and are almost always located in either open canopy sites or above the canopy of adjacent trees (Kurta et al. 1996, 2002; Callahan et al. 1997). Primary roosts are usually not located in densely forested areas, but rather occur along forest edges or within gaps in forest stands where they receive greater solar radiation (USFWS 2007a, 2007b), a factor that may be important in reducing thermoregulatory costs for reproductive females and their young (Vonhof and Barclay 1996). Female Indiana bats are able to use torpor to conserve energy during cold temperatures; however, torpor slows gestation (Racey 1973), milk production (Wilde et al. 1999), and juvenile growth, and it is costly when the reproductive season is short (Hoying and Kunz 1998, Barclay and Kurta 2007).

The distribution of Indiana bat summer habitat in the east appears to be less extensive than in the Midwest (see range maps in USFWS 2007a), which may be due to the geographic distribution of important hibernacula or to differences in climate and elevation that may limit suitable summer colony sites in this location. The summer temperatures of portions of Indiana bat range in the east are slightly cooler than in the core part of the range in Indiana, Kentucky, and Missouri (Brack et al. 2002, Woodward and Hoffman 1991), and temperatures typically decrease at increasing elevation (conditions may also become wetter), which may influence the energetic feasibility of reproduction in some areas (Brack et al. 2002). Researchers in Virginia found that there is a 6.4 °C (11.5 °F) decrease in temperature for each increase of 1,000 m (3,300 ft) in elevation (Woodward and Hoffman 1991).

In the northeastern portions of the range, elevation appears to influence likely presence of maternity colonies (Brack et al. 2002). For example, roost trees in the Champlain Valley of Vermont and New York occur at elevations much lower (i.e., 30-150 m [100-490 ft] above sea level [ASL]) than the surrounding mountains, which have maximum elevations of 1,340 m (4,400 ft) and 1,330 m (4,360 ft) ASL (Britzke et al. 2006, Watrous et al. 2006). The Champlain Valley roosts are the farthest north of any known Indiana bat maternity roosts (USFWS 2007a) at approximately 44° north (N). The Clayton maternity roost is the farthest north Indiana bat roost known in Jefferson County, New York, at 44° 13.32 N. All maternity roosts in New York to date have been located at or below 274 m (900 ft) in elevation. However, Indiana bat maternity colonies are found at higher elevations at lower latitudes.

Maternity roosts in West Virginia have been recorded at elevations between 290 m (950 ft) and 914 m (3,000 ft) ASL (C. Stihler, West Virginia Department of Natural Resources [WVDNR], pers. comm.). The farthest south and highest known elevation for a female roost tree recorded to date was found at 1,158 m (3,800 ft) ASL in the Nantahala National Forest in

Tennessee/North Carolina (Britzke 2003). The specific location is not reported, but the latitude near the center of the Nantahala National Forest is 35.2° N. It is worth noting that the females tracked to this Nantahala Forest roost were not located in subsequent years, despite known philopatry to maternity roosts by Indiana bats (USFWS 2007a), so the viability of these locations for maternity roosting is debatable. Brack et al. (2002) found it unlikely that Indiana bats reproduce at higher elevations in the three eastern states evaluated in their study (West Virginia, Virginia, and Pennsylvania).

Indiana bats from the same maternity colony may use between 10 and 20 trees throughout the summer, but usually only one to three of these are considered primary roosts, where the majority of Indiana bats roost for part or all of the summer (Callahan 1993, Callahan et al. 1997). Alternate roost trees are typically used by individuals or small groups for only one day or a few days. On average, Indiana bats switch roosts every two to three days, although reproductive condition of the female, roost type, and time of year affect switching (Kurta et al. 2002, Kurta 2005).

While the primary and alternate roosts of a maternity colony may change over the years, it is thought that foraging areas and travel corridors are relatively stable (Barclay and Kurta 2007). Members of a maternity colony in Michigan used a wooded fence line as a travel corridor for nine years (Winhold et al. 2005). In general, the distance from the roost tree to foraging areas varies from 0.5 to 8.4 km (0.3 to 5.3 mi; USFWS 2007a); this distance may be constrained by the need to return to the roost periodically to nurse once the young are born (Henry et al. 2002). Lactating females have been shown to return to the roost two to four times during a night (Butchkoski and Hassinger 2002, Murray and Kurta 2004). In Pennsylvania, the mean distance from the roost to the nearest edge of a foraging area was 2.7 km (1.7 mi) and ranged from 1.3 to 5.3 km (0.8 to 3.3 mi; Butchkoski and Turner 2005). In Indiana, 11 females used foraging areas on average 3.0 km, range 0.8 to 8.4 km (1.9 mi, range 0.5 to 5.3 mi), from their roosts (Sparks et al. 2005); and, in Michigan, the distance between roosts and foraging areas was 2.4 km, range 0.5 to 4.2 km (1.5 mi, range 0.3 to 2.6 mi; Murray and Kurta 2004). In areas of low-density forested habitat (approximately 2% forested area) in Ohio, the maximum foraging distances for lactating females from the primary roost tree were 9.4 to 10.8 km (5.9 to 6.7 mi) (K. Lott, USFWS, pers. comm.).

Although individuals from a maternity colony appear to show fidelity to a general home range within and between years (Sparks et al. 2004), due to the differences in methodology it is difficult to determine a common home range size (Lacki et al. 2007). In Indiana, mean home range was 145 ± 18 ha (358 ± 44 ac; Sparks et al. 2005); while on the Vermont-New York state line it was 83 ± 83 ha (205 ± 203 ac; Watrous et al. 2006). Both of these estimates are higher than for a single female in Pennsylvania, whose home range was estimated at 21 ha (52 ac; Butchkoski and Turner 2006). As well as differences in methodology, the range of home ranges estimated likely reflects differences in habitat quality between sites.

3.2.2.4 Fall Migration and Swarming

Indiana bats start leaving their summer habitat as early as late-July and begin arriving at hibernacula in August (USFWS 2007a). Limited telemetry studies during spring and fall migration indicate that Indiana bats may migrate simultaneously, though perhaps independently (S. Darling, Vermont Department of Fish and Wildlife, pers. comm. 2010, Chenger, BCM, pers. comm. 2011, R. Reynolds, Virginia Department of Game and Inland Fisheries [VDGIF], pers. comm. 2010, as cited in USFWS 2011a; Hicks et al. 2012). Because female Indiana bats are likely cued into the same climatic or environmental stimuli during the spring and fall migration, there may be migratory pulses of Indiana bats moving through an area, and it is reasonable to assume that at least some individuals leave summer colonies together or at least contemporaneously (L. Pruitt, USFWS, pers. comm. 2011, Reynolds, VDGIF, pers. comm. 2010, as cited in USFWS 2011a). However, given that females from the same maternity colony do not all hibernate in the same hibernaculum (though some do; Kurta and Murray 2002, Winhold and Kurta 2006), at least some females likely migrate independently.

Little is known about Indiana bat behavior during fall migration compared to spring migration. This is due, at least in part, to the ease of capturing and tagging bats roosting in hibernacula prior to spring dispersal compared to capturing bats dispersed throughout their summer habitat prior to fall migration. Many Indiana bats have been captured and tracked from their hibernacula to their summer ranges, providing information on spring migration movements and timing (Table 4.2 in Stantec Consulting, Inc. [Stantec] 2013). Consequently, most of what is known about fall migration comes from band returns (i.e., individuals that are banded during the summer and subsequently documented during winter hibernacula counts), which provide information about migration distances and beginning and ending destinations, but not information about timing or migration routes. However, it is thought that fall migration takes longer and is less direct than the relatively direct and short-term spring migration (USFWS 2013d).

Studies indicate that Indiana bat migration from winter to summer habitat is fairly linear and short-term, while in the fall it may be more dispersed and varied (USFWS 2007a, Hicks et al. 2012). In addition, males and females appear to display different dispersal behavior, with females moving relatively quickly between the hibernacula and maternity colonies, while males commonly remain in the proximity of the hibernacula or travel between hibernacula (USFWS 2007a).

Data regarding the height at which Indiana bats fly during migration are lacking. However, it is clear that at least a portion of myotid bats are flying well above the tree canopy at rotor-swept height during fall migration, considering that six of the eight Indiana bat fatalities that have been documented to date at wind energy facilities occurred during the fall migration period (Pruitt and Okajima 2014), as well as the documented mortality of many other myotids at other wind energy facilities occurring primarily during late summer and fall (M. Seymour, USFWS, pers. comm. 2015; USFWS unpublished data as cited in 2011a). However, data indicate that the cave-dwelling bat species are probably not flying within the rotor-swept zone as frequently as long-distance migrating tree bats; of all bat mortalities detected at wind energy facilities within the range of the Indiana bat, myotids and tri-colored bats (*Perimyotis subflavus*) compose less than 10% of the total bat fatalities (USFWS unpublished data, as cited in USFWS 2013d).

This assumption is supported by anecdotal and empirical data that suggest that Indiana bats primarily migrate at the tree canopy level (Turner 2006; L. Robbins, Missouri State University, pers. comm. 2010; C. Butchkoski, Pennsylvania Game Commission [PGC], pers. comm. 2010, C. Herzog New York State Department of Environmental Conservation [NYSDEC], pers. comm. 2011 as cited in USFWS 2011a). Data from Indiana bat radio-tracked in spring in the northeast showed that Indiana bats closely follow topographic features, such as meandering stream corridors and utility ROWs for miles, and over multiple years (Chenger, BCM, pers. comm 2011, Turner, PGC, pers. comm. 2011, as cited in USFWS 2011a). Similar findings have been documented in Tennessee and Illinois, indicating that Indiana bats may be flying near canopy height during migration (Gumbert et al. 2011, Hicks et al. 2012). However, it is uncertain if flight heights suggested in these studies would be similar to other portions of the species' range. Further, it is unknown whether flight heights during spring and fall migration are similar.

When Indiana bats arrive at hibernacula, they perform a behavior known as swarming, in which they fly around the entrances in an attempt to find mates (Cope and Humphrey 1977). Once arriving at hibernacula, females may only remain active for a few days, whereas males remain active, seeking mates, into late October and early November (timing varies with latitude and annual weather conditions). During the swarming period, most male Indiana bats roost in trees in the area surrounding hibernacula during the day and fly to the hibernacula at night (USFWS 2007a). Clusters of active Indiana bats have also been observed roosting in caves during swarming events (Gumbert et al. 2002).

The maximum distance between identified roost trees and associated hibernacula varies among telemetry studies conducted during the fall roosting and swarming season. Most telemetry studies conducted during fall swarming have occurred outside of hibernacula with relatively small populations of Indiana bats. At two small P3 hibernacula in Kentucky, Indiana bats roosted primarily within 2.4 and 4.1 km (1.5 and 2.5 mi) of the cave entrances (Kiser and Elliot 1996, Gumbert 2001). In Virginia, all roost trees identified from eight male and three female Indiana bats were within 1.4 km (0.9 mi of a P3 hibernaculum[6] (Brack 2006). In Michigan, Kurta (2000) tracked two male Indiana bats to roost trees located 2.2 and 3.4 km (1.4 and 2.1 mi) from a P4 hibernaculum.

Indiana bats were documented roosting further from hibernaculum in areas with larger populations of hibernating Indiana bats. Outside of the Canoe Creek Mine (with a hibernating population of 774 Indiana bats in 2007), a male Indiana bat twice traveled 14 km (8.7 mi) from the hibernaculum where it was captured (USFWS 2007a). In Missouri, radio-tagged Indiana bats traveled maximum distances of 6.4 km (4.0 mi) away from the nearby hibernacula that had a collective hibernating population of 2,495 individuals (Rommé et al. 2002). During telemetry studies outside Wyandotte Cave in Indiana, two female Indiana bats were relocated 30.7 km

[6] The author noted that Indiana bats traveling outside of the study area (defined as the north side of a 3.2-km [2.0-mi] circle, centered on the hibernaculum) were not able to be located.

(19.1 mi) away from the cave (Hawkins et al. 2005, USFWS 2007a). The longer distances traveled by Indiana bats at larger hibernacula seem to suggest that the density of bats influenced how Indiana bats used the areas surrounding hibernacula (Hawkins et al. 2005). As the density of bats swarming outside of the hibernaculum increases, Indiana bats may need to move farther from the site to find available roost and prey resources.

Indiana bats tend to roost more often as individuals in fall than in summer (USFWS 2007a). Roost switching occurs every two to three days and trees used by the same individual tend to be clustered. Similar to summer roosts, fall roost trees most often are in sunny forest openings created by natural or human disturbance (USFWS 2007a). Indiana bats show strong site fidelity (especially females) and typically return to the same hibernacula year after year (Hall 1962, LaVal and LaVal 1980, Gumbert et al. 2002). However, an Indiana bat captured during swarming at the Canoe Creek Mine in fall 2007 was captured in a cave in Tucker County, West Virginia, in winter 2009-2010, a distance of approximately 214 km (133 mi; Butchkoski, PGC, pers. comm., Stihler, WVDNR, pers. comm.). Similarly, a female Indiana bat that was captured emerging from the South Penn Tunnel in Bedford County, Pennsylvania, in the spring of 2007 was recaptured in winter 2009-2010 at Hellhole cave in Pendleton County, West Virginia, a distance of approximately 138 km (86 mi; Butchkoski, pers. comm., Stihler, WVDNR, pers. comm.). Hall (1962) also reported Indiana bats apparently switching between hibernacula.

3.2.2.5 Effects of Temperature on Bat Migration

In terms of the effect of temperature on migration, positive correlations of bat activity and temperatures are common in bat literature, both over an annual time period (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991) and on a nightly basis (Lacki 1984, Hayes 1997, Vaughan et al. 1997, Gaisler et al. 1998, Shiel and Fairley 1998). Bat experts consulted by the USFWS (2011e) noted that weather conditions that impair flight, impair the ability to thermoregulate, or reduce insect activity, such as heavy rain, high wind, heavy fog, and cold (some specifically cited temperatures below 10 to 13 °C [50 to 55 °F]), are likely to result in reduced bat activity among all bat species. Data obtained from fatality monitoring at wind energy facilities also suggests correlations between weather conditions (i.e., temperature, wind speeds, and storm fronts) and bat activity.

Post-construction monitoring conducted during the fall (i.e., August 1 – October 15, 2010) at the Fowler Ridge Wind Farm (FRWF) in Indiana (Good et al. 2011, 2012, 2013a) show that 0.3%, 1.0%, and 1.8% of all fresh bat casualties occurred during nights when the average nightly temperature was below 10 °C (50 °F) in 2010, 2011, and 2012, respectively. During the FRWF studies, average nightly temperatures below 10 °C occurred about 4.1%, 2.7% and 9.5% of the time in 2010, 2011 and 2012, respectively. No *Myotis* carcasses were found when average nightly temperatures were below 10 °C at the FRWF. The average nighttime temperature during the evening when an Indiana bat carcass was found at the FRWF in fall 2010 was 21 °C (69.8 °F; Good et al. 2011), which was slightly above the average nighttime temperature for the period of study.

At the Timber Road II Wind Energy Facility (TRII) in Ohio, 2.1% and 2.6% of all bat casualties occurred during nights when the average nightly temperature was below 10 °C in 2011 and 2013. Average nightly temperatures below 10 °C occurred at TRII on 20.4% of nights in 2011 (July 31-November 15) and 20.6% of nights in 2013 (March 31-November 15) during the periods of mortality monitoring. No *Myotis* carcasses were found when average nightly temperatures were below 10 °C at TRII (Ritzert et al. 2012 and Simon et al. 2014).

Two Indiana bat carcasses have been found at TRII (Pruitt and Okajima 2014). Temperatures associated with nights when the two Indiana bat fatalities occurred were well above 10 °C. One Indiana bat was found on October 10, 2013; the carcass was decomposed and was estimated to have been killed four to seven days prior to the date of collection. This placed the estimated time of death during the nights of October 3, 4, 5, or 6. Average nighttime temperatures during these dates ranged from 20.3 – 21.7 °C (68.5 – 71.1 °F), which was warmer than most other nights in October and November (Simon et al. 2014).

The second Indiana bat carcass at TRII was found on April 14, 2014; the carcass was fresh and estimated to have been killed the previous night. The average temperature on the evening of April 13 was 19.6 °C (67.3 °F) and ranged from 17.4– 22.5 °C (63.3 – 72.5 °F). The average temperature during the spring migration period (i.e., April 1 – May 14) was 11.1 °C (52.0 °F). The night of April 13 was the 5th warmest night of the 46 days in the spring migration season (Good et al. 2015).

No site specific temperature data are publically available for wind facilities where other fresh Indiana bat fatalities have been documented (see Pruitt and Okajima 2014 for other Indiana bat fatalities). Historic weather data for locations as close as possible to these wind facilities are as follows: Valparaiso, Indiana, September 8-9, 2009 – minimum temperature: 16-17 °C (60-62 °F); Valparaiso, Indiana, September 17, 2010 – minimum temperature: 16 °C (60 °F); Cresson, Pennsylvania, September 25, 2011 – minimum temperature: 14 °C (57 °F); Elkins, West Virginia, July 7, 2012 – minimum temperature: 18 °C (65 °F); Lima, Ohio, October 2-3, 2012 – minimum temperature: 16-17 °C (53-57 °F).

Average nightly temperatures in the Permit Area were below 10 °C 50.0% of time during the spring migration period (March 15 – May 15) and 2.6% of time during the fall migration period (August 1 – October 15) during monitoring conducted in 2015 (Good et al. 2016a, Section 3.4). Because cut-in wind speeds (i.e., the wind speed at which turbines begin generating electricity) were raised to 6.9 m per second (m/s; 22.6 ft/s) for the majority of the monitoring period, which resulted in a small sample size of bat carcasses available for comparison to temperature data, no appropriate data are available to assess bat fatality rates below 10 °C for the Project. One Indiana bat carcass has been documented in the Permit Area (see Section 3.4.1 for a description of the circumstances around this event). The carcass was found on August 23, 2015, with an estimated time since death of seven to 14 days. The average nightly temperatures from August 9 to 23, 2015 never fell below 10 °C and were 21.5 °C (70.7 °F) on average (Good et al. 2016a, Section 3.4.1).

Although 10 °C may not be a "hard cut-off" for Indiana bat activity, this temperature is expected to represent a threshold below which minimal activity is expected to occur (USFWS 2011a). Post-construction monitoring data from TRII and the FRWF have shown that only a small percentage of bat mortality occurs when temperatures are below the 10 °C threshold.

3.2.3 Demographics

Little is known about annual survival rates for Indiana bats, either for adults or juveniles (USFWS 2007a). It is expected, however, that similar to many other species, survival of Indiana bats is lowest during the first year of life and threats and sources of mortality vary during the annual cycle. During summer months, sources of mortality may include loss of occupied forested habitat, predation, human disturbance, and other man-made disturbances (Kurta et al. 2002; USFWS 2007a, 2007b). Sources of winter mortality may include natural predation, natural disasters that impact hibernacula, disturbance or modifications at the hibernacula and surrounding areas that physically disturb the bats or change the microclimate within the hibernacula, and direct human disturbance during hibernation that leads to disruption of normal hibernation patterns (USFWS 2007a).

Currently, the disease known as white-nose syndrome (WNS) is the most severe threat facing Indiana bat populations range-wide (USFWS 2009). WNS was first discovered during the winter of 2006 in four caves in New York and has since spread steadily in all directions (see White-Nose Syndrome.org 2017). The disease infects hibernating bats and is caused by a fungal pathogen (*Pseudogymnoascus destructans* [*Pd*]; Blehert et al. 2009, 2011; Minnis and Lindner 2013). To-date, the disease is responsible for more than 5.7 million bat fatalities in eastern North America (USFWS 2012d). See Section 3.5.1 for a detailed discussion of WNS and its effects on Indiana bats.

In a study in Indiana, survival rates among male and female Indiana bats ranged from 66% to 76% for six to 10 years after marking, with female longevity being approximately 12 to 15 years and for males being about 14 years (Humphrey and Cope 1977). The oldest known Indiana bat was recaptured 20 years after the first capture (LaVal and LaVal 1980). Research from banding studies during the 1970s suggests that adult Indiana bat survival during the first six years varies from approximately 70%-76% annually (i.e., an average of 70%-76% of the group studied survived each year; Humphrey and Cope 1977, O'Shea et al. 2004, USFWS 2007a). After this period, annual survival varied from 36%-66%, and after 10 years, dropped to approximately 4% (Humphrey and Cope 1977). There is less information available on neonatal survival, with one published study suggesting a neonatal survival rate of 92% based on observations at a maternity colony over a single season (Humphrey et al. 1977). More research is needed to accurately define annual survival rates of Indiana bats; however, available information suggests that annual mortality is likely to be between 8% and 64% during the first 10 years of life (USFWS 2007a).

O'Shea et al. (2004) summarized survival rates for a number of species, including the little brown bat, which is considered a similar species to the Indiana bat in terms of life history. The range of annual survival rates cited varied considerably from approximately 13%-86% (O'Shea et al. 2004). Other *Myotis* species also had variable annual survival rates, ranging from about 6%-89%; however, studies indicated that survival for first-year juveniles was generally lower than for adults in general. The sex ratio of the Indiana bat is generally reported as equal or nearly equal, based on early work by Hall (1962), Myers (1964), and LaVal and LaVal (1980). Humphrey et al. (1977) observed a nearly even sex ratio (nine females, eight males) in a sample of weaned young Indiana bats. However, differential survival in adults has been suggested (Humphrey and Cope 1977, LaVal and LaVal 1980).

As with mortality or survival rates for Indiana bats, relatively little is known about recruitment rates for the species; however, female Indiana bats typically give birth to one young per year (Mumford and Calvert 1960, Humphrey et al. 1977, Thomson 1982). The proportion of females in a population that produce young in a year is thought to be fairly high (USFWS 2007a). In one study, greater than 90% of the females produced young each year (Humphrey et al. 1977), and in another study, it was estimated that 89% of adult females were reproductively active annually (Kurta and Rice 2002).

Location and environmental factors likely influence reproductive rates and there is concern that environmental threats such as WNS may lead to lower reproduction rates (USFWS 2011b). The 2007 Draft Indiana Bat Recovery Plan divides the species' range into four recovery units based on several factors, such as traditional taxonomic studies, banding returns, and genetic variation (USFWS 2007a). Recruitment in the total Indiana bat population in recent years has been variable by recovery unit, with the Ozark-Central Recovery Unit and the Midwest Recovery Unit (MRU) being relatively stable since 2007 (USFWS 2015a; Figure 3.2). Both the Northeast Recovery Unit and the Appalachian Recovery Unit have decreased substantially in recent years (USFWS 2015a; Figure 3.2), most likely due to WNS. The Northeast Recovery Unit showed the largest percentage decline from 2007 to 2011 (70%; reduced by 37,639 bats); whereas the Appalachian Recovery Unit showed the largest decline from 2013 to 2015 (70%; reduced by 12,326 bats; USFWS 2015a).

3.2.4 Range and Distribution

The range of the Indiana bat includes most of the eastern US (Figure 3.2; Saugey et al. 1990, Clark et al. 1987, Evers 1992, Kurta and Teramino 1994, Kurta 1995).

Over the past 40 years, general population trends of Indiana bats appear to be decreasing in the south and increasing in the northern regions of its range (USFWS 2007a, 2010). The species has disappeared from or greatly declined in most of its former range in the northeast (e.g., Trombulak et al. 2001). Historically, Indiana bat winter range was restricted to areas of cavernous limestone in the karst regions of the east-central US, apparently concentrated in a relatively small number of large, complex cave systems. These included Wyandotte Cave in Indiana; Bat, Coach, and Mammoth Caves in Kentucky; Great Scott Cave in Missouri; and Rocky Hollow Cave in Virginia (USFWS 2007a).

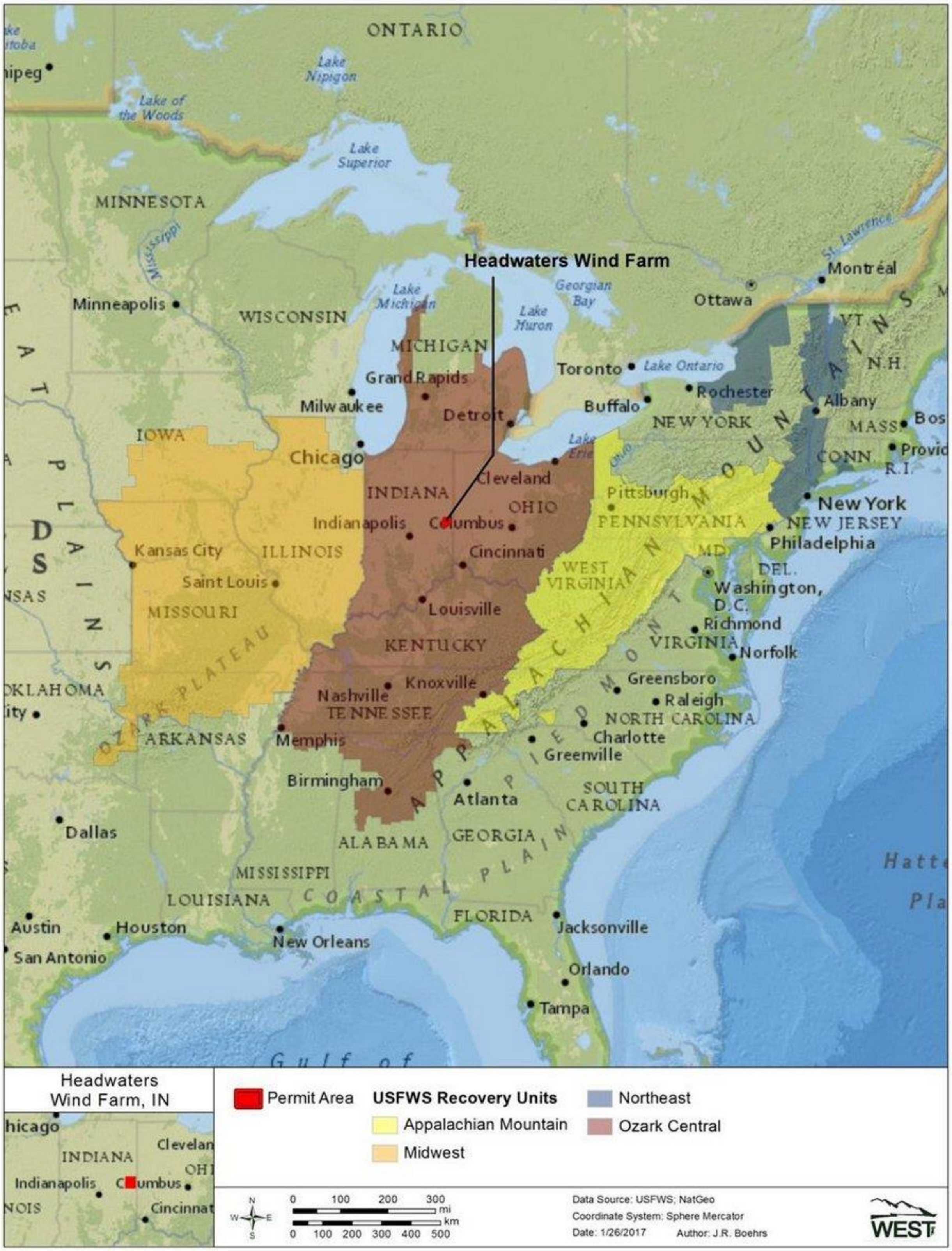

Figure 3.2 Range of the Indiana bat as shown by the US Fish and Wildlife Service Indiana bat Recovery Units.

More recently, increasing numbers of Indiana bats have been found using man-made structures, such as mines, tunnels, and buildings for hibernation, extending their winter range into some caveless parts of the country (Kurta and Teramino 1994). For example, approximately 123,000 Indiana bats were recently discovered in a previously unknown hibernacula in Missouri (USFWS 2013a). Indiana bats also have been found hibernating in several man-made tunnels (Butchkoski and Hassinger 2002), and in 1993, an Indiana bat was discovered hibernating in a hydroelectric dam in Manistee County, Michigan, 450 km (281 mi) from the closest recorded hibernaculum for Indiana bat in LaSalle County, Illinois (Kurta and Teramino 1994). In 2005, approximately 30% of the population hibernated in man-made structures (predominantly mines) with the rest using natural caves (USFWS 2007a). As of November 2006, there were 281 known extant Indiana bat hibernacula in 19 states (USFWS 2007a). In 2013, over 90% of the population hibernated in just five states: Indiana (45.2%), Missouri (14.2%), Kentucky (13.6%), Illinois (9.7%), and New York (9.1%); with 71.6% hibernating in just 10 hibernacula (USFWS, unpublished data 2006, as cited by USFWS 2007a; Figure 3.3).

Relatively little is known about the historic summer range of Indiana bats. It is believed that the historical summer distribution for this species was similar to that of today; however, the first maternity colony was not discovered until 1971 (Cope et al. 1974). As of October 2006, the USFWS had records of 269 maternity colonies in 16 states (USFWS 2007a; Figure 3.4). This likely represents only about 6-9% of the 2,859 to 4,574 colonies thought to exist based on the estimated total wintering population (Whitaker and Brack 2002, USFWS 2007a).

The distribution of Indiana bat summer habitat in the east appears to be less extensive than in the Midwest (see range maps in USFWS 2007a), which may be due to the geographic distribution of important hibernacula or to differences in climate and elevation that may limit suitable summer maternity colony sites in the east. Summer temperatures of portions of Indiana bat range in the east are slightly cooler than in the core part of the range in Indiana and Kentucky, which may influence the energetic feasibility of reproduction in eastern areas (see Woodward and Hoffman 1991, Brack et al. 2002).

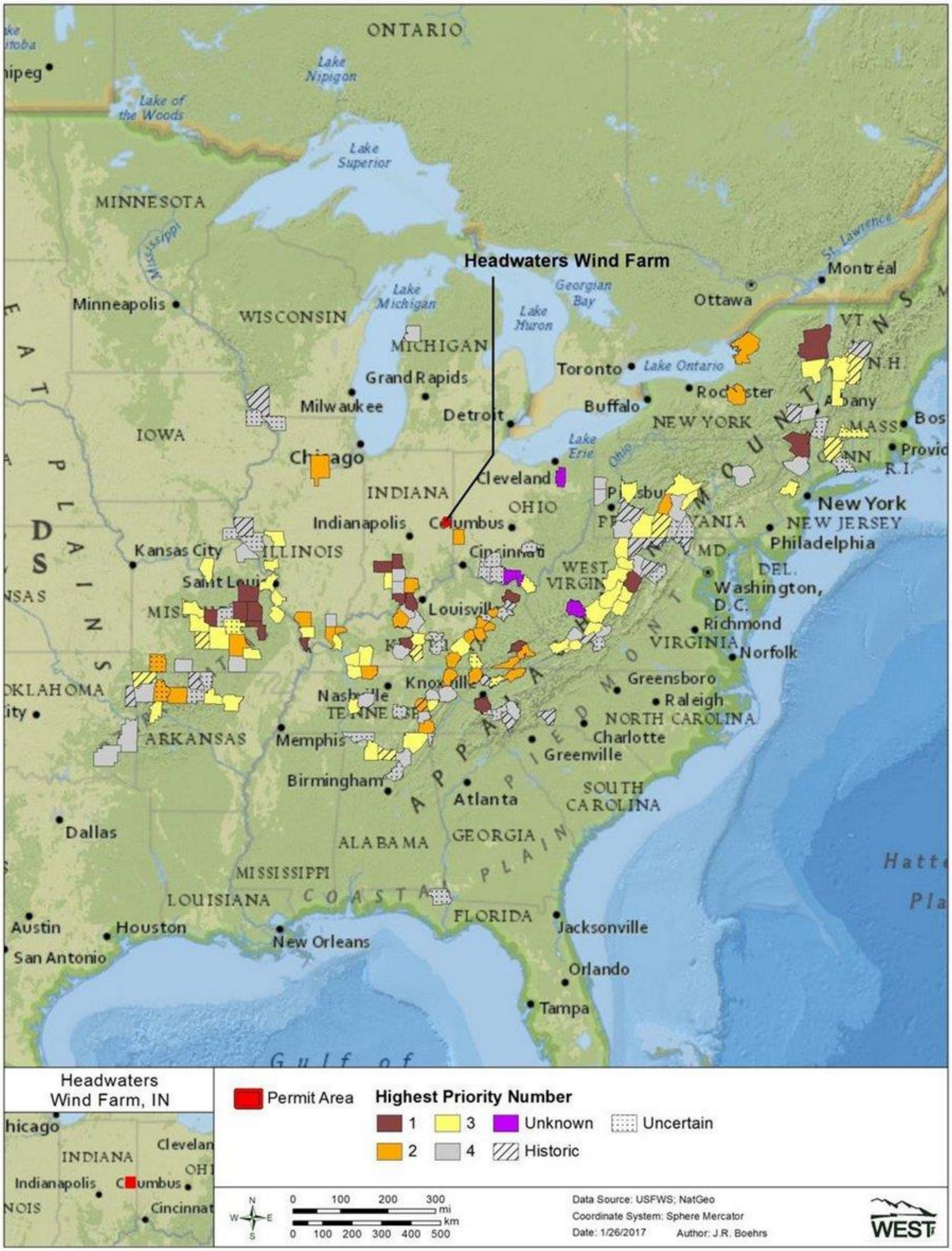

Figure 3.3 Indiana bat hibernacula as classified by the US Fish and Wildlife Service.

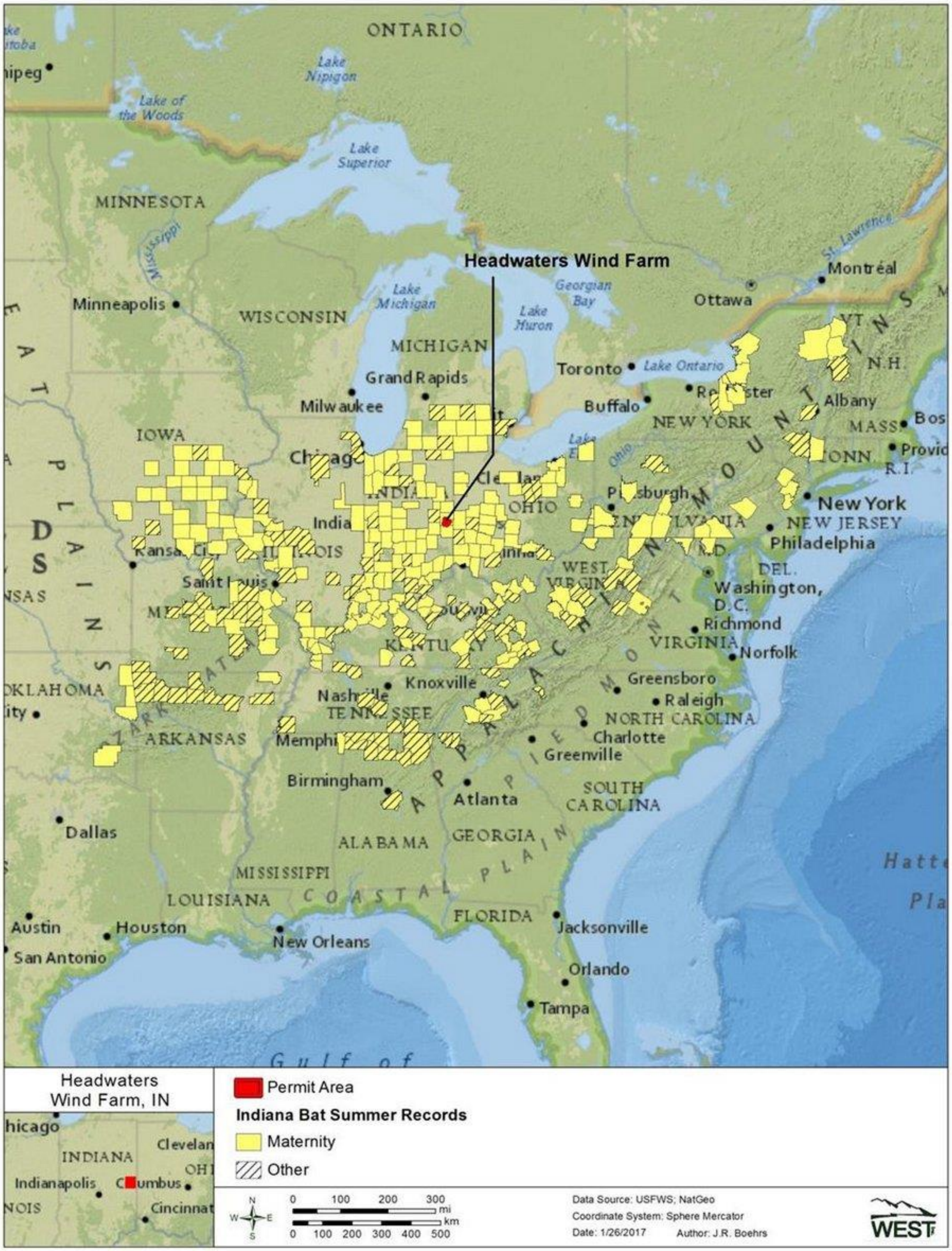

Figure 3.4 Indiana bat summer records as documented by the US Fish and Wildlife Service.

3.2.5 Species Status and Occurrence

The Indiana bat was determined to be an endangered species in 1967 (USFWS 1967) under the Endangered Species Preservation Act of 1966, prior to the enactment of the ESA in 1973. Important hibernation caves and mines used by Indiana bats during winter are designated as critical habitat for the species, but no critical habitat is located within the Permit Area. At the time of listing, primary threats to the species were believed to include loss of habitat and human disturbance, especially at winter hibernacula, and potentially ineffective management due to a general lack of knowledge about the species' biology and distribution (USFWS 1999). The 2007 Draft Indiana Bat Recovery Plan lists as threats to the species destruction/degradation of hibernation habitat; loss/degradation of summer, migration, and swarming habitat; disturbance of hibernating bats; disturbance of summering bats; disease and parasites; and natural factors and anthropogenic factors (USFWS 2007a). As previously stated, WNS is currently the most severe threat facing Indiana bat range- wide populations (USFWS 2009; see Section 3.5.1 for a detailed discussion of WNS and its effects on Indiana bats).

3.2.5.1 Range-wide

The USFWS implements a biennial monitoring program at P1 and P2 hibernacula (USFWS 2007a). In 1965, the overall population was estimated to be over 880,000 individuals; however, while variation in the data collection apparently has led to variable estimates, and in general, there has been a long-term declining population trend, with approximately 451,600 individuals reported in 2001 (USFWS 2013a). After 2001, there was a gradual population increase to 590,875 Indiana bats in 2007 (USFWS 2013a); however, the estimated population fell to 530,705 Indiana bats in 2017 (USFWS 2017). A high proportion of that decline (more than 50%) is likely due to the effects of WNS (see Thogmartin et al. 2012, 2013).

General patterns in the overall population estimates have shown a decreasing trend through the core range of the Indiana bat in the Midwest and increasing trends on the periphery and more northern states (USFWS 2007a). The causes of these population changes are unknown; however, climate change may play a role by negatively affecting hibernacula temperature (USFWS 2007a). More recently, Indiana bat populations in the Eastern Recovery Unit, Appalachian Mountain Recovery Unit, and MRU (see below) have been affected by WNS.

3.2.5.2 Midwest Recovery Unit

The Project falls within the MRU that includes the states of Indiana, Kentucky, Ohio, Tennessee, and Alabama, as well as southwestern Virginia, southern Michigan, and northwest Georgia (USFWS 2007a, Figure 3.2).

According to the *2017 Rangewide Population Estimate for the Indiana Bat (Myotis sodalis) by USFWS Region* (2017 Range-Wide Population Estimate; USFWS 2017), the overall population within the MRU was 281,971 Indiana bats in 2009, 308,352 Indiana bats in 2011 (an increase of 9.1%), 300,699 Indiana bats in 2013, 257,748 Indiana bats in 2015 (a decrease of 14.3% since 2013), and 243,403 Indiana bats in 2017 (a decrease of 5.6% since 2015; Table 3.2). The MRU represents 45.9% of the 2017 range-wide population of Indiana bats (USFWS 2017). According to the 2007 Draft Indiana Bat Recovery Plan, there are 190 known Indiana bat hibernacula within the MRU, with 116 being classified as extant (i.e., having at least one recorded Indiana bat during census counts since 2000; USFWS 2007a). There are 12 P1 hibernacula in the MRU: seven in Indiana and five in Kentucky.

Table 3.2 Indiana bat population estimates for the Midwest Recovery Unit (USFWS 2017).

State	2009	2011	2013	2015	2017
Indiana	213,244	225,477	226,572	185,720	180,583
Kentucky	57,319	70,626	62,018	64,571	58,155
Ohio	9,261	9,870	9,259	4,809	2,890
Tennessee	1,657	1,791	2,369	2,401	1,598
Alabama	253	261	247	90	85
SW Virginia	217	307	214	137	70
Michigan	20	20	20	20	20
Georgia	0	0	0	0	1
Total	**281,971**	**308,352**	**300,699**	**257,748**	**243,402**

3.2.5.3 Indiana

The estimated population size of Indiana bats in Indiana peaked in 2007 and remained fairly stable from 2011 to 2013, but then dropped thereafter (Table 3.2; USFWS 2017), likely due to WNS. In 2017, approximately 34% of the estimated range-wide population of Indiana bats hibernated in Indiana, and 74% of the MRU population hibernated in Indiana (USFWS 2017). There are 37 known Indiana bat hibernacula in the state and of these, 34 have extant winter populations (at least one record since 2000; USFWS 2007a). Of the extant Indiana hibernacula, seven are classified as P1, one is P2, 15 are P3, nine are P4, and two of the hibernacula are unclassified (USFWS 2007a). The P1 hibernaculum, Wyandotte Complex in Crawford County, was estimated to have 126,448 Indiana bats in 2007 (USFWS 2008). All of the hibernacula in Indiana are found in the south-central part of the state within the Interior Plateau Ecoregion (USFWS 2007a).

The summer range of Indiana bats in Indiana is fairly ubiquitous. At the time of publication of the 2007 Draft Indiana Bat Recovery Plan, 51 counties in Indiana (out of 92 total counties) had records of summer maternity colonies; an additional 14 counties had other summer records of Indiana bats and one county had winter records only. Section 3.4.1 provides information on the occurrence of Indiana bats in the Permit Area.

3.3 Covered Species – Northern Long-Eared Bat

The northern long-eared bat is a small (5.0 and 8.0 g [0.2 and 0.3 oz]) insectivorous bat. Compared to other *Myotis* species, the northern long-eared bat has long ears with a relatively long tragus; when folded forwards, the ears extend well past the nose. Northern long-eared bats also have a longer tail and larger wing area than most comparably sized *Myotis* bats, giving them increased maneuverability during slow flight (Caceres and Barclay 2000). The fur color can be medium to dark brown on the back and tawny to pale-brown on the underside. The northern long-eared bat was formerly considered a subspecies of Keen's bat (*Myotis keenii*), though they are now considered to be two genetically distinct species (Caceres and Pybus 1997; Center for Biological Diversity 2010). Most literature prior to the 1980s under the name Keen's bat actually pertains to the northern long-eared bat.

3.3.1 Life History Characteristics

Northern long-eared bats exhibit life history traits similar to those of Indiana bats and other temperate bat species. Like most bats, northern long-eared bats are relatively long-lived (see Caceres and Pybus 1997). Similar to most temperate *Myotis* species, female northern long-eared bats give birth to one offspring per year (Barbour and Davis 1969). Mating occurs in the vicinity of hibernacula from late July in northern regions to early October in southern regions and commences when males begin to swarm at hibernacula and initiate mating activity (Whitaker and Hamilton 1998, Caceres and Barclay 2000, Amelon and Burhans 2006, Whitaker and Mumford 2009). Mating also occasionally occurs again in the spring (Racey 1982). Hibernating females store sperm until spring, employing a delayed fertilization strategy (Racey 1979, Caceres and Pybus 1997).

In spring, female northern long-eared bats leave hibernacula and form maternity colonies ranging from seven to 100 individuals, but most commonly 30-60 individuals (USFWS 2014b). Birthing within the colony tends to be synchronous, with the majority of births occurring around the same time (Krochmal and Sparks 2007). Parturition dates and subsequent weaning are likely dependent on regional conditions (Foster and Kurta 1999). Parturition likely occurs in late May or early June (Easterla 1968, Caire et al. 1979, Whitaker and Mumford 2009), but may occur as late as July (Whitaker and Mumford 2009). Studies completed by Broders et al. (2006) over a 3-year period in New Brunswick, Canada found parturition to occur in mid- to late-July. Other studies suggest that southeastern population parturition dates occur between mid-May and mid-June (Cope and Humphrey 1972, Caire et al. 1979).

Generally, female northern long-eared bats roost communally, while males select solitary roosts (Caceres and Barclay 2000). Northern long-eared bats have shown site fidelity related to summer roost habitat, but use a number of roost trees in an area, switching between trees every one to three days (Foster and Kurta 1999, Arnold 2007, Timpone et al. 2010). Movement back to hibernacula for fall swarming and hibernation occurs at the end of the summer maternity season, as early as late July and extending as late as October (Whitaker and Hamilton 1998, Caceres and Barclay 2000, Amelon and Burhans 2006, Whitaker and Mumford 2009).

Northern long-eared bats are likely opportunistic insectivores that primarily glean prey from substrates (Faure et al. 1993). They are known to forage under the forest canopy at small ponds or streams, along paths and roads, or at the forest edge (Caire et al. 1979).

3.3.2 Habitat Requirements

3.3.2.1 Winter Habitat

Mine and cave sites have been most often reported as hibernacula for northern long-eared bats (Griffin 1940, Whitaker and Winter 1977, Stones 1981). This species reportedly hibernates in caves or abandoned mines with Indiana bats, little brown bats, big brown bats (*Eptesicus fuscus*), and tri-colored bats (Mills 1971, Caire et al. 1979, Boyles et al. 2009). Northern long-eared bats generally compose a small proportion of the hibernating population of bat species in a given hibernaculum (less than 1% to 15%) (Griffin 1940, Hitchcock 1949, Pearson 1962, Caire et al. 1979, Stones 1981).

Hibernating northern long-eared bats do not form large aggregations or clusters typical of some eastern species. Instead, individuals or small groups seem to favor deep crevices for hibernation (Caceres and Barclay 2000), and very few hibernating individuals can be found even in caves known to serve as hibernacula (Whitaker et al. 2002). Rarely are there more than 100 individuals documented per hibernation colony (Barbour and Davis 1969, Caire et al. 1979), though mist-netting surveys conducted at cave and mine entrances suggest that northern long-eared bats are much more numerous than the numbers documented by counts of hibernating individuals (Whitaker et al. 2002).

Northern long-eared bats generally exhibit strong philopatry to hibernacula, but have also been reported to occasionally move between hibernacula during the winter (Whitaker and Rissler 1992, USFWS 2014b).

3.3.2.2 Spring Emergence and Migration

There is little information available regarding spring emergence and dispersal of northern long-eared bats from hibernacula. According to the *Northern Long-Eared Bat Interim Guidance and Planning Guide* (Northern Long-Eared Bat Interim Guidance), the primary spring migration season is from the beginning of April to mid-May (USFWS 2014b). As with Indiana bats, the actual migration periods may vary by latitude and weather, with spring emergence occurring earlier in more southern areas and fall migration occurring earlier in more northern areas (USFWS 2014b).

Shortly after emergence, northern long-eared bats migrate to their summer habitat. Although species-specific data are lacking, the spring migration direction of northern long-eared bats may be similar to the migration direction documented for little brown bats, meaning that northern long-eared bats may radiate outward from hibernacula during migration and migrate directly to the natal sites, rather than moving primarily north or south (Davis and Hitchcock 1965, Fenton 1970, Griffin 1970, Humphrey and Cope 1976). Short migratory movements between 56 to 89 km (35 to 55 mi) from hibernacula to summer habitat are most common (Griffin 1945, Nagorsen and Brigham 1993), suggesting the species is a regional migrant. The longest recorded migration distance for the species is 97 km (60 mi), reported by Griffin (1945).

Little is known about male northern long-eared bat migrations, but male little brown and Indiana bats have been captured outside of known hibernacula in midsummer, suggesting that some males may migrate short distances from their hibernacula (Davis and Hitchcock 1965, Gardner and Cook 2002, Whitaker and Brack 2002). If male northern long-eared bats behave similarly to other *Myotis* species, then it can be expected that they form small bachelor colonies or stay close to known hibernacula (Davis and Hitchcock 1965). However, records of non-reproductive male northern long-eared bats have been documented in 64 counties in northeastern, northwestern, and southern Ohio, including Van Wert, Ashtabula, and Lawrence counties, locations distant from any known nearby hibernacula (Lott, USFWS, pers. comm.).

3.3.2.3 <u>Summer Habitat</u>

Northern long-eared bats most frequently select mature-growth forests with decaying trees and/or live trees with cavities or exfoliating bark during the summer maternity season (Foster and Kurta 1999, Lacki and Schwierjohann 2001, Ford et al. 2006). Day and night roosts are utilized by northern long-eared bats during spring, summer, and fall, with old-growth forest communities selected most frequently (Foster and Kurta 1999, Owen et al. 2003, Broders and Forbes 2004). Variation in roost selection criteria has been reported between northern long-eared bat sexes, with females forming maternity colonies in snags and solitary males roosting in live tree cavities (Caceres and Barclay 2000, Lacki and Schwierjohann 2001, Broders and Forbes 2004).

Broders and Forbes (2004) further reported that northern long-eared bat maternity colonies were more often in shade- tolerant deciduous stands and in tree species that are susceptible to cavity formation. This is supported by Lacki and Schwierjohann's (2001) findings that colony roosts were more likely to occur in stands with higher density of snags. Though some may roost alone, females often roost colonially. Maternity colonies are generally small, consisting of 30 (Whitaker and Mumford 2009) to 60 (Caceres and Barclay 2000) individuals, though maternity colonies of up to 100 individuals have been observed (Layne 1978, Dickinson et al. 2009, Whitaker and Mumford 2009).

Northern long-eared bats do not typically forage in intensively harvested stands or open agricultural areas, and instead concentrate their movement in and near intact forest (Patriquin and Barclay 2003, Henderson and Broders 2008). However, in areas where forest has a patchy distribution, northern long-eared bats are forced to move across open agricultural areas to reach nearby forest. In northwestern Ohio, the smallest forested patch where a northern long-eared bat was captured was 0.7 ha (1.8 ac); in Van Wert County, the smallest patch of forest where northern long-eared bats were captured was 1.9 ha (4.7 ac; Lott, USFWS, pers. comm.).

Northern long-eared bats are known to forage under the forest canopy at small ponds or streams, along paths and roads, or at the forest edge (Caire et al. 1979). Northern long-eared bats have low wing loading, a low aspect ratio, and are highly maneuverable in forested habitat and therefore are well-adapted to foraging in dense vegetation (Patriquin and Barclay 2003, Carter and Feldhamer 2005). This species is also frequently observed to forage in close proximity to ephemeral upland pools (Owen et al. 2003, Brooks and Ford 2005). In managed forests of West Virginia, northern long-eared bats utilized on average a 65-ha (160.6-ac) home range and patches smaller than this likely represent unsuitable habitat (Owen et al. 2003). Females have been reported to move up to approximately 2,000 m (6,500 ft) and males up to approximately 1,000 m (3,300 ft) between roost sites (Broders et al. 2006).

A radio-telemetry study of seven northern long-eared bats (two male and five female bats) and five Indiana bats (all male bats) at the Wayne National Forest in Ohio found significant differences in roost selection between the two species (Schultes and Elliott 2002). Northern long-eared bats exhibited a wider roosting niche than Indiana bats, using both bark and cavity roost in live and dead trees. Northern long-eared bat roost trees had significantly higher basal area (23 m^2/ha versus [vs.] 15 m^2/ha) and percent shrub cover within five m of the tree (44% vs. 23%) than Indiana bat roost trees and were located in slightly younger forest stands (76 years vs. 86 years), although it was noted that average stand age is not representative of the possible range in tree age within a stand. Northern long-eared bat roosts were located farther from water (117 m vs. 27 m [384 ft vs. 89 ft]), but closer to mist-net sites (0.3 km vs. 1.6 km [0.2 mi to 1.0 mi]) than Indiana bat roosts, suggesting that northern long-eared bats had shorter nightly travel distances at the Wayne National Forest. Northern long-eared bat roosts were associated with upper slopes and ridgetops, although the authors noted that this association may have been the result of a limited sample size. Both northern long-eared bats and Indiana bats selected for roost trees located closer (80-100 m [262-328 ft]) to roads and trails, possibly making use of these areas as flyways between roost trees and foraging areas. Both species changed roosts regularly and at similar rates during the study, including in response to the loss of two roost trees that were identified by the study as an ephemeral resource (Schultes and Elliott 2002).

3.3.2.4 Fall Migration and Swarming

According to the Northern Long-Eared Bat Interim Guidance, the primary fall migration period is from mid-August to October (USFWS 2014b). Even less is known about behavior of northern long-eared bats during migration, such as flight heights, echolocation frequency, influence of weather, or whether they migrate singly or in groups, than is known about Indiana bats.

Data regarding the height at which northern long-eared bats fly during migration are lacking. No radio-telemetry studies have been conducted to date to study the migration behavior of northern long-eared bats. However, as described for Indiana bats, it is clear that at least a portion of myotid bats are flying well above the tree canopy at rotor-swept height during migration, based on the 36 northern long-eared bat fatalities that have been publically documented to date at wind energy facilities, occurring primarily during late summer and fall[7]. However, data indicate that the cave-dwelling bat species are probably not flying within the rotor-swept zone as frequently as long-distance migrating tree bats. Of all bat mortalities detected at wind energy

[7] Stantec 2007, 2011;, Kerns and Kerlinger 2004; Arnett et al. 2005; Grehan 2008; James 2008; Jacques Whitford 2009; Jain et al. 2009, 2011; Young et al. 2009, 2013; Good et al. 2011; Kerlinger et al. 2011; J. Taucher, PGC, pers. comm.

facilities within the range of the northern long-eared bat, myotids and tri-colored bats compose only about 10% of the total bat fatalities (USFWS unpublished data, as cited in USFWS 2011a).

Northern long-eared bats begin arriving at hibernacula in August, and by mid-September large numbers can be seen flying about the entrances to certain caves and mines (Boyles et al. 2009). Mating occurs during this fall swarming period around hibernacula (USFWS 2014b).

3.3.2.5 Effects of Temperature on Bat Migration

As described in Section 3.2.2.5, positive correlations of bat activity and temperature are common in bat literature, both over an annual time period (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991) and on a nightly basis (Lacki 1984, Hayes 1997, Vaughan et al. 1997, Gaisler et al. 1998, Shiel and Fairley 1998). Bat experts consulted by the USFWS noted that weather conditions that impair flight, impair the ability to thermoregulate, or reduce insect activity, such as heavy rain, high wind, heavy fog, and cold (some specifically cited temperatures below 10 to 13 °C [50 to 55 °F]), are likely to result in reduced bat activity among all bat species (USFWS 2011a). Data obtained from fatality monitoring at wind energy facilities also suggests correlations between weather conditions (i.e., temperature, wind speeds, and storm fronts) and bat activity.

Although 10 °C may not be a "hard cut-off" for northern long-eared bat activity, this temperature is expected to represent a threshold below which minimal activity is expected to occur (USFWS 2011a). Post-construction monitoring data from TRII and the FRWF showed only a small percentage of bat mortality occurred when temperatures were below the 10 °C threshold (see Section 3.2.2.5).

3.3.3 Demographics

Similar to other *Myotis* bat species, northern long-eared bat has a comparatively low reproductive rate, with females birthing one offspring per year (Barclay et al. 2004; Barbour and Davis 1969 as cited by USFWS 2016b). The sex ratio in northern long-eared bat populations appears to be dominated by males with multiple studies reporting higher percentages of males compared to females (Griffin 1940, Hitchcock 1949, Pearson 1962, Stones 1981). The skewed ratio is believed to be due to greater mortality among females. The northern long-eared bat is a fairly long-lived species (Thompson 2006), with one individual reported living up to 19 years (Hall et al. 1957).

There is little information regarding survival trends for the northern long-eared bat because only a few individuals have been banded and low population levels are resulting in extremely low capture rates, inhibiting the banding of more individuals USFWS 2015b. There is no available information on recruitment rates or the proportion of females in a population that produce young in a year for northern long-eared bats.

3.3.4 Range and Distribution

The northern long-eared bat is found in 39 states in the eastern and Midwestern US and across the northern Great Plains; the species also occurs across eastern and central Canada (USFWS 2014b; Figure 3.5). The species occurs in a widespread, but irregular, patchy distribution, rarely occurs in large numbers (Barbour and Davis 1969), and is more common in the northern part of its range (Harvey 1992). Barbour and Davis (1969) reported that the winter and summer geographic ranges of the species appear to be identical.

3.3.5 Species Status and Occurrence

The life history of the northern long-eared bat makes this species particularly vulnerable to a variety of threats. Because of the species' low reproductive rate (see Section 3.3.3), populations of northern long-eared bats are likely slow to recover from the loss of individuals, increasing the possibility that mortality caused by WNS (see Section 3.5.1), development, or other factors will cause extirpation (e.g., USGS 2009). Although population trends have not historically been recorded for the species, it is understood that WNS is currently causing severe population declines in the eastern parts of the species' range. Other sources of mortality may further diminish the species' ability to persist in areas where populations are significantly reduced due to WNS. The USFWS listed the northern long-eared bat as a threatened species under the ESA (80 FR 17974; USFWS 2013c, 2015b).

The final 4(d) Rule for the species published January 14, 2016 (81 FR 1900) exempts from the Section 9 take prohibition the incidental take of northern long-eared bats resulting from most otherwise lawful activities[8], including incidental take of northern long-eared bats due to the operation of wind turbines. The USFWS further concluded that the designation of critical habitat was not determinable at the time of listing (USFWS 2013c).

[8] The final 4(d) Rule published January 14, 2016 (81 FR 1900), exempts all incidental take of northern long-eared bats caused by otherwise lawful activities from the take prohibition under Section 9 of the ESA, except: take of northern long-eared bats in their hibernacula in areas affected by WNS; take resulting from tree removal within0.4 km (0.25 mi) of a known northern long-eared bat hibernaculum; and take resulting from removal of a known northern long-eared bat maternity roost tree or tree removal within a 45-m (150-ft) radius of a known northern long- eared bat maternity roost tree during the pup season (June 1 through July 31). Incidental take resulting from hazard tree removal for protection of human life and property is exempt from the take prohibition regardless of where and when it occurs.

Figure 3.5 Geographic range of northern long-eared bat in the US and Canada (USFWS 2014b).

3.3.5.1 Range-Wide

Little is known about overall population size or trends of northern long-eared bat within its range. Across its range, the northern long-eared bat occurs in a widespread but irregular, patchy distribution, rarely in large numbers (Barbour and Davis 1969). Despite its broad range, the species has historically been most common in the Northeast and Midwest, with lower densities known in the southern and western portions of the range (USFWS 2013c). WNS is the most severe threat facing northern long-eared bat populations range-wide and is the primary reason the species was listed as threatened under the ESA (80 FR 17974; see Section 3.5.1).

Across the species' range, northern long-eared bat population trends have not been historically monitored. Hibernating northern long-eared bats do not form large aggregations or clusters typical of some eastern species. Instead, individuals or small groups seem to favor deep crevices for hibernation (Caceres and Barclay 2000) and very few hibernating individuals can be found even in caves known to serve as hibernacula (Whitaker et al. 2002). For example, small population size is characteristic of all recorded occurrences in hibernacula (Schmidt 2001) and there are rarely more than 100 individuals documented per hibernaculum (Barbour and Davis 1969, Caire et al. 1979).

Given its tendency to hibernate individually or in small groups, it is difficult to obtain accurate counts of wintering numbers of northern long-eared bats. However, mist-netting surveys suggest that northern long-eared bats are more numerous than hibernacula counts detect (Whitaker et al. 2002). Before the advent of WNS in 2006, adequate data to assess broad-scale population trends were not available, although some studies reported stable populations within portions of the species' range (e.g., Trombulak et al. 2001). Before WNS, the northern long-eared bat was common in northeastern US bat surveys; after the arrival of WNS, survey numbers for northern long-eared bats declined to zero in many hibernacula (Hicks et al. 2008).

The current range-wide and Indiana population estimates for the northern long-eared bat, as published in the *Programmatic Biological Opinion on 4(d) Rule for the Northern Long-eared Bat and Activities Exempted from Take Prohibition* (Table 2.4 in USFWS 2016e) are 6,546,718 and 127,842 adults, respectively.

3.3.5.2 Indiana

Northern long-eared bats have been recorded at 25 hibernacula consisting of abandoned mines, caves, and tunnels in Indiana (Whitaker and Hamilton 1998 as cited in 80 FR 17974). Historically, the northern long-eared bat was considered quite common throughout much of Indiana and was the fourth or fifth most abundant bat species in the state in 2009 (Whitaker and Mumford 2009 as cited in 80 FR 17974). Based on a review of mist-netting surveys in Indiana, Whitaker et al. (2002) estimated the state's northern long-eared bat population to be approximately 471,217 bats. Northern long-eared bats have been captured in at least 51 counties in Indiana, were often captured in mist-nets along streams, and were the most common bat captured by trapping at mine entrances (Whitaker and Mumford 2009 as cited in 80 FR 17974). The abundance of northern long-eared bats appears to vary within Indiana during the summer. During three summers (1990-1992) of mist-netting surveys in the northern half of

Indiana, 37 northern long-eared bats were captured at 22 of 127 net sites, representing 4% of the bats captured (King 1993 as cited in 80 FR 17974). However, during three summers (2006-2008) of mist-netting surveys on two state forests in south-central Indiana, northern long-eared bats were the most common (38%) species captured (Sheets et al. 2013 as cited in 80 FR 17974). The northern long-eared bat's range includes all 92 counties in Indiana (USFWS 2016f); more information is needed on the location of hibernation sites and maternity colonies for the species within these counties.

Although data are not currently available to assess the population trend of northern long-eared bats in Indiana, WNS has been present in the state since the winter of 2010-2011 (Indiana Department of Natural Resources [IDNR] 2011, White-Nose Syndrome.org 2017) and there is no reason to believe WNS will not have a similar impact on northern long-eared bat populations in Indiana as it has had on northern long-eared bat populations in the northeast (80 FR 17974).

Refer to Section 3.4.2 for information on the occurrence of northern long-eared bats in the Permit Area.

3.4 Occurrence of the Covered Species in the Permit Area/Local Population

The following sections summarize pre- and post-construction monitoring studies that were conducted in the Permit Area and help inform the magnitude and seasonality of risk for the Covered Species.

3.4.1 Indiana Bats

Three active maternity colonies have been documented in Randolph County, and most of the surrounding counties have summer capture records (USFWS 2007a). The nearest known winter population to the Project is a P2 hibernaculum (Lewisburg Mine) located approximately 38 km (24 mi) to the southeast in Preble County, Ohio (USFWS 2007a).

Results from acoustic monitoring studies conducted from July 14 through October 18, 2010, both within and outside[9] of the Permit Area indicate that *Myotis* species[10] are present during the late summer and fall migration season (Good et al. 2014a). A total of 2,027 echolocation calls (28% of all calls recorded) were identified as *Myotis* species. Most of these calls (1,892 calls; 93%) were recorded at temporary acoustic monitoring stations set up near bat habitat features (e.g., woodlots, forested riparian corridors) and away from where the Project turbines are located. A total of 135 *Myotis* calls (7%) were recorded at fixed acoustic monitoring stations located on temporary meteorological towers. Of these calls, 128 (95%) were recorded at ground detectors and seven (5%) were recorded by detectors raised to 50 m (164 ft; within the rotor-swept zone), indicating that most *Myotis* activity occurred below the rotor-swept area of the Project turbines.

[9] Three fixed-station detectors and seven temporary-station detectors were placed to the west of the Permit Area.

[10] The acoustic analysis identified bats down to the species group level, which grouped the little brown bats, northern long-eared bats, eastern small-footed bats (*M. leibii*), and Indiana bats into the *Myotis* species group (MYSP).

The *Myotis* pass rate and *Myotis* percent composition of recorded calls peaked at the fixed acoustic monitoring stations within the Permit Area during the week of August 13-19, 2010, and remained relatively high through the week of September 3-9, 2010 (Figure 3.6, Table 3.3). The *Myotis* pass rate and percent composition were low after September 9 through the end of the study period, indicating that *Myotis* activity in the vicinity of Project turbines occurs mostly during August and the first half of September. Similar patterns in *Myotis* activity were observed at the fixed and temporary acoustic monitoring stations outside of the Permit Area, with peaks in pass rate and percent composition occurring the weeks of July 30-August 5, 2010, and August 13-19, 2010, respectively (Table 3.3). *Myotis* activity was recorded at the temporary acoustic monitoring stations within the Permit Area only during the weeks of July 16-22 and 23-29 (most activity) and August 6-12, 2010 (very low activity), although it is worth noting that, due to detector malfunctions, no data were recorded in the second half of August at those detectors (Table 3.3).

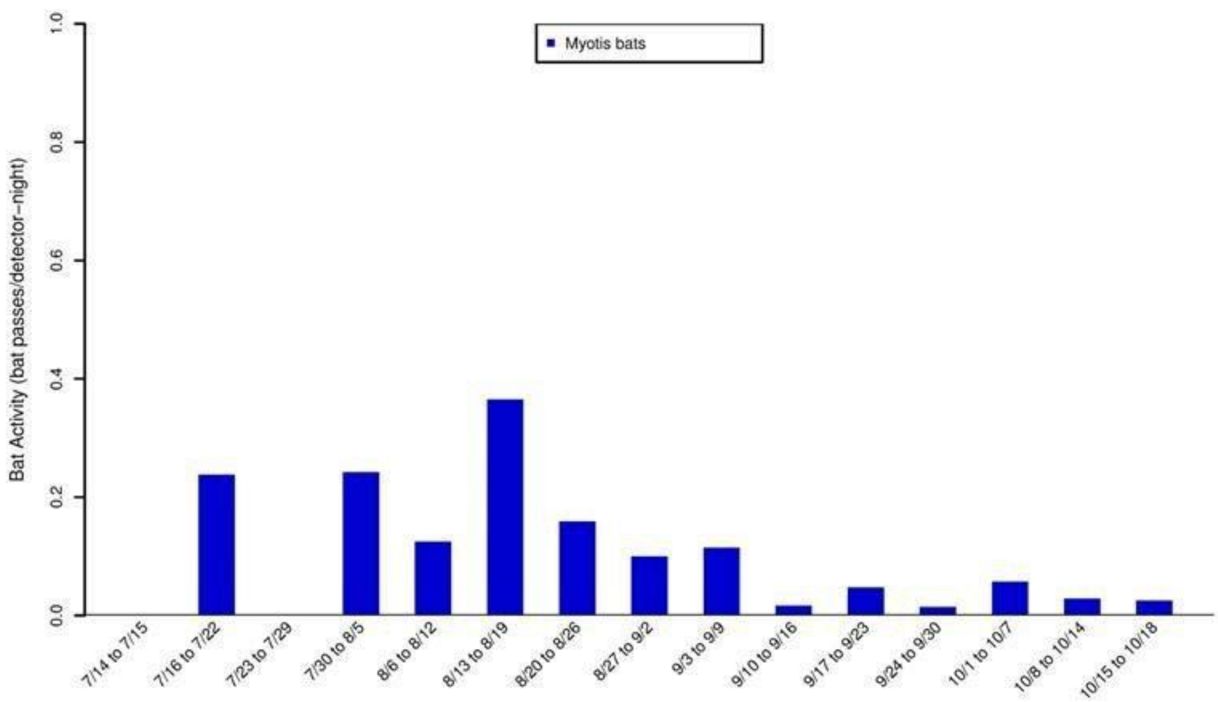

Figure 3.6 *Myotis* activity recorded at fixed acoustic monitoring stations within the Headwaters Wind Farm Permit Area, July 14 to October 18, 2010.

Table 3.3 *Myotis* activity recorded at fixed and temporary acoustic monitoring stations within and outside of the Headwaters Permit Area, July 14 to October 18, 2010.

	Within Headwaters Project Boundary				Outside Headwaters Project Boundary			
	Fixed Stations		Temporary Stations		Fixed Stations		Temporary Stations	
Week	Bat Passes/ Detector Night	% Comp	Bat Passes/ Detector Night	% Comp	Bat Passes/ Detector Night	% Comp	Bat Passes/ Detector Night	% Comp
07/14/10 - 07/15/10	0	0	0	0	0	0	9	4.5
07/16/10 - 07/22/10	0.24	15.5	45.3	33	0.17	14.6	9	4.5
07/23/10 - 07/29/10	0	0	91.71	66.7	0.12	10.5	3.86	1.9
07/30/10 - 08/05/10	0.24	15.8	0	0	0.19	16.7	NaN	NaN
08/06/10 - 08/12/10	0.12	8.2	0.43	0.3	0.11	10	41	20.4
08/13/10 - 08/19/10	0.37	23.8	NaN[1]	NaN	0.14	12.6	68.29	34
08/20/10 - 08/26/10	0.16	10.4	NaN	NaN	0.06	5	8.14	4.1
08/27/10 - 09/02/10	0.1	6.5	NaN	NaN	0.06	5	0	0
09/03/10 - 09/09/10	0.11	7.5	0	0	0.11	10	NaN	NaN
09/10/10 - 09/16/10	0.02	1.1	0	0	0.06	5	38	18.9
09/17/10 - 09/23/10	0.05	3.1	0	0	0	0	23.25	11.6
09/24/10 - 09/30/10	0.01	0.9	0	0	0.07	6.3	0.25	0.1
10/01/10 - 10/07/10	0.06	3.7	0	0	0.05	4.2	0	0
10/08/10 - 10/14/10	0.03	1.9	0	0	0	0	NaN	NaN
10/15/10 - 10/18/10	0.02	1.6	0	0	0	0	NaN	NaN

[1] No data were collected at temporary stations during this period.

NaN = Not a Number

Mist-net surveys conducted at nine sites in and around a former Project boundary[11] in June 2010 captured seven Indiana bats, including five pregnant females and two lactating females (Murray et al. 2011). Two of the captured pregnant females were tracked to a single maternity roost tree located just outside of the former Project boundary on the banks of the Little White River. Exit counts indicated that the tree was a primary roost tree for the maternity colony. In addition, Indiana bat echolocation calls were located at two sites near the Little White River and were associated with Indiana bat capture sites. Three of the 2010 mist-net locations were located within the Permit Area; no Indiana bats were captured at those locations. After these surveys were completed, the Applicant relocated the Project approximately 10 km (6 mi) to the east of the former boundary due to development considerations. The Permit Area is located east of the Indiana bat capture and roost locations.

The Permit Area and 2010 survey results were reviewed by the USFWS Indiana Field Office (INFO) which recommended surveys at six additional sites within the Permit Area to determine if summer populations of Indiana bats were present. The mist-net survey was conducted at six sites within the Permit Area during late July and early August 2013 (Libby 2013). No Indiana bats were captured during this survey.

To further evaluate potential risk to Indiana bats, a spatial analysis was conducted following the USFWS *Indiana Bat Section 7 and Section 10 Guidance for Wind Energy Projects* (USFWS 2011a) to determine the locations of 2010 Indiana bat capture and roost locations relative to the Permit Area[12]. The spatial analysis determined that all turbines are outside of the 4.0-km (2.5-mi) buffers of documented roost trees (USFWS 2011a). One turbine (turbine 18094 on the western edge of the Permit Area) was found to be within 8.0 km (5.0 mi) of an Indiana bat capture location. However, based on subsequent mist-netting in the Permit Area in 2013 which confirmed probable absence of Indiana bats, turbine 18094 is not expected to present risk to Indiana bats during the summer.

Two turbines (turbines 12024 and 12025) located in the northernmost area of the Project were added to the layout after the 2013 surveys (see Figures 1.2 and 3.1). The USFWS conducted

---

[11] The Project was relocated approximately 10 km (6 mi) to the east of the former boundary due to development considerations.

[12] The 2011 guidance states that if only capture information is available (and no roost tree information), the USFWS assumes the maternity colony home range may include all suitable habitat within 8 km of the capture location. If roost tree(s) have been documented (through telemetry associated with the project or any other effort) but no foraging data are available, the USFWS assumes the maternity colony home range includes: 1) all suitable habitat within 4.0 km of the single documented maternity roost tree unless the distance between the capture location and roost tree is larger (in that case, the longer distance is used to create the polygon); 2) all suitable habitat within 4.0 km of the line drawn between the two documented roost trees unless the distance between the capture location(s) and roost trees is larger (in that case, the longer distance is used to create the polygon); and 3) all suitable habitat within 4.0 km of the center of the polygon created by connecting three or more documented roost trees unless the distance between the capture location(s) and roost trees is larger (in that case, the longer distance is used to create the polygon). If roost tree(s) have been documented and foraging points and/or acoustic data are available, the home range is defined by mapping the potential home range following steps for "capture and roost trees"; determining whether all telemetry points are included within the polygon: If yes, consider that all suitable habitat within 4.0 km of documented roosts is part of the home range; if no, all telemetry points are included as part of the home range.

an Indiana bat habitat assessment in March 2014 near these two new turbines and determined that a woodlot was connected to a forested riparian corridor of the White River where previous Indiana bat captures have been recorded. Therefore, the woodlot near these two turbines was determined to have the potential for summer Indiana bat use (M. Reed, USFWS, pers. comm.).

In summary, based on the results of acoustic monitoring surveys, it is assumed that Indiana bats may occur within the Permit Area during the fall migration season (August 1-October 15). The mist-net surveys and USFWS habitat assessment indicate that Indiana bats may occur in woodlots near turbines 12024 and 12025 on the northern edge of the Permit Area during the summer maternity season (May 15-July 31). It can be reasonably assumed that spring migrating bats move towards summer use areas; therefore, Indiana bats may also occur in the woodlot near turbines 12024 and 12025 during the spring migration season (April 1-May 14). Based on documentation of an Indiana bat fatality during the spring migration season at a wind energy facility in Ohio that lacks summer habitat (most [98%] of the land cover where the bat was found consists of cropland and developed areas [Pruitt and Okajima 2014]), it is also assumed that Indiana bats could, on occasion, occur elsewhere within the Permit Area during spring. Indiana bats are not expected to occur within the Permit Area during the fall swarming season (October 15-November 15) based on the lack of known hibernacula in the Permit Area vicinity.

During 2015, the first year of Project operations, the Applicant's goal was to implement avoidance measures for the Covered Species recommended by the USFWS (Pruitt 2014), including feathering turbines below wind speeds of 5.0 m per second (m/s; 16.4 ft/s) and 6.9 m/s during the spring and fall, respectively, at all turbines, and 6.9 m/s during summer at the four turbines located near potential suitable summer habitat for the Covered Species. Post-construction monitoring was conducted from March 15 through October 15, 2015, according to a USFWS recommended protocol (Good et al. 2016a). During a regularly scheduled search, an Indiana bat carcass was found on August 23, 2015, with an estimated time since death of seven to 14 days. The Applicant determined that the turbine at which the Indiana bat was found was not curtailed properly from August 1 to September 4, 2015, and immediately corrected the turbine programming for proper curtailment. The Indiana bat was determined to have been killed during the period of curtailment failure due to the high searcher efficiency rates and the estimated time since death. The sex and age of the Indiana bat could not be determined due to the decomposition state of the carcass. The results of the 2010 and 2013 summer presence/absence surveys (which included the area where the Indiana bat was found) and the occurrence of the fatality at the end of the USFWS-defined maternity season suggested the Indiana bat was migrating or was conducting post-maternity season movements.

During 2016 and 2017, the Project was operated according to the avoidance measures for the Covered Species recommended by the USFWS (Pruitt 2014). During a regularly scheduled search in 2017, an Indiana bat carcass was found on August 10 and estimated to have perished at least 14 to 30 days prior to the discovery, resulting in an estimated time of death in July. The turbine where the Indiana bat was found was not curtailed to avoidance during July because the USFWS and Applicant had not previously identified the turbine as presenting a risk of summer take for the Covered Species. The sex and the age of the bat could not be determined when inspected in person or through genetic analysis, but the estimated time of death indicates that the bat occurred near the turbine during the summer maternity season. The Indiana bat may have been associated with a maternity colony nearby because there is one forested woodlot of roughly 6.8 ha (16 ac) in size located approximately 130 m (425 ft) from the turbine. There are also a number of other smaller woodlots and shelterbelts near this turbine. An analysis of the connectivity of this woodlot to other forested areas indicated that there are six turbines, including the turbine at which the Indiana bat was found, located within 1,000 ft of these forested areas that may present a risk to bats using the woodlot during the summer season.

3.4.2 Northern Long-Eared Bats

The locations of northern long-eared bat maternity colonies and hibernacula are largely unknown in Indiana. Although data are not currently available to assess the distribution and abundance of the local population of northern long-eared bats, the pre-construction surveys provide information about the occurrence of northern long-eared bats within the Permit Area.

Mist-net surveys conducted at nine sites in and around a former Project boundary in June 2010 captured three northern long-eared bats, including one non-reproductive adult male, one pregnant adult female, and one lactating adult female (Murray et al. 2011). As described in Section 3.4.1, the Project was relocated approximately 10 km to the east of the former boundary after these surveys were conducted due to development considerations. The mist-net site at which the male northern long-eared bat was captured was located west of the Permit Area; no turbines are located within the 4.8-km (3.0-mi) home range (as defined in the Northern Long-Eared Bat Interim Guidance) buffer of this capture. The 2010 mist-net site at which the two females were captured was located in the western part of the Permit Area, near turbines 18095 and 18096 (see Figures 1.2 and 3.1). The mist-net surveys conducted within the Permit Area during late July and early August 2013 did not result in any captures of northern long-eared bats, indicating that while northern long-eared bats may continue to occur during the summer in the woodlot near turbines 18095 and 18096, they are not expected to occur elsewhere in the Permit Area during the summer (May 15-July 31; Libby 2013).

In summary, based on the results of acoustic monitoring surveys (refer to Section 3.4.1; Good et al. 2014a), it is assumed that northern long-eared bats may occur within the Permit Area during the fall migration season (August 1-October 15). The mist-net surveys indicate that northern long-eared bats may occur in the woodlot near turbines 18095 and 18096 in the western part of the Permit Area during the summer maternity season (May 15-July 31), but are not expected to occur elsewhere in the Permit Area during summer. It can be reasonably assumed that spring migrating bats move towards summer use areas; therefore, northern long-eared bats may also occur in the woodlot near turbines 18095 and 18096 during the spring migration season (April 1-May 14). Based on documentation of an Indiana bat fatality during the spring migration season at a wind energy facility in Ohio that lacks summer habitat (Pruitt and Okajima 2014), it is also assumed that other *Myotis* bats, such as northern long-eared bats, could on occasion occur elsewhere within the Permit Area during spring. Northern long-eared bats are not expected to occur within the Permit Area during the fall swarming season (October 15-November 15) based on lack of known hibernacula in the Permit Area vicinity.

No northern long-eared bats have been found at the Project during post-construction monitoring (Good et al. 2016a), as expected due to the Applicant's goal of implementing avoidance measures for the Covered Species recommended by the USFWS (Pruitt 2014).

3.5 White-Nose Syndrome and Other Threats to the Covered Species

3.5.1 White-Nose Syndrome

White-nose syndrome is the most severe threat facing Indiana and northern-long eared bat populations range-wide (USFWS 2009, 2014c). White-nose syndrome was first discovered during the winter of 2006/2007 in four caves in Schoharie County, New York, and has since spread steadily in all directions (IDNR 2011, USFWS 2015c, White-Nose Syndrome.org 2017). By 2010, WNS had been documented in all known Indiana bat hibernacula in New York (Frick et al. 2010). Bats infected with WNS were first confirmed in Indiana during the winter of 2010-2011 (IDNR 2011).The origin of WNS remains uncertain, although anthropogenic introduction of the disease from Europe via cavers or commerce has been presented as a plausible hypothesis (Frick et al. 2010). To-date, the disease is responsible for more than 5.7 million bat fatalities in eastern North America (USFWS 2012d, 2016c).

Recent research has shown that the fungal agent, *Pd*, is the causative agent in the bat deaths (Lorch et al. 2011). There is now strong support that WNS increases the frequency and duration of arousal bouts in hibernating bats and causes the premature expenditure of energy stores (Reeder et al. 2012, Verant et al. 2014). In addition to observed fatalities at hibernacula, WNS has also been linked to decreased bat abundance in summer habitat (Brooks 2010 , Dzal et al. 2010). If current trends for spread and mortality continue at affected sites, WNS threatens to drastically reduce the abundance of Indiana bat and northern long-eared bats throughout their ranges and potentially cause local extirpation.

The effects of WNS appear to be realized over a prolonged period. Large population declines have been observed over a 5- to 6-year period from the onset of the disease. Within a 5-state area affected by WNS for multiple years (New York, Pennsylvania, Vermont, Virginia, West Virginia), population monitoring at 42 hibernacula documented a 98% decline in northern long-eared bats and a 72% decline in Indiana bats (Turner et al. 2011).

Thogmartin et al. (2012) estimated that between 1983 and 2005, the range-wide Indiana bat population was generally stable, with some subpopulations increasing and others decreasing. However, since the onset of WNS in 2006, the range-wide Indiana bat population has experienced steady annual declines and the authors concluded that WNS is having an appreciable influence on trends of Indiana bat populations, stalling and in some cases reversing population gains made in the previous 20 years. White-nose syndrome is consequently expected to be the factor that has the greatest short-term and long-term impact upon the Indiana bat range-wide population (USFWS 2009).

The northern-long eared bat is one of the species most impacted by WNS (USFWS 2015c). As previously stated, Turner et al. (2011) found a 98% decline in the number of hibernating northern long-eared bats since initial WNS infection at 30 hibernacula in New York, Pennsylvania, Vermont, Virginia, and West Virginia. The USFWS (2013c) conducted a similar analysis for an additional 12 hibernacula in Connecticut, Massachusetts, New Hampshire, and Vermont, and found the combined overall rate of decline in the eight states was approximately 99%. These states were also historically the core part of the species range, where the species was most abundant. White-nose syndrome is currently invading into areas in the Midwest that contain a number of large and important hibernacula, and population declines similar to those observed in the Northeast are expected over the next few years in the Midwest (USFWS 2013c).

The life history of the northern long-eared bat makes this species particularly vulnerable to a variety of threats. Because of their low reproductive rate, populations of northern long-eared bats are likely slow to recover from the loss of individuals, increasing the probability that mortality caused by WNS, development, or other factors will cause extirpation (e.g., USFWS 2009). Although population trends have not historically been recorded for the northern long-eared bat, it is understood that WNS is currently causing severe population declines in the eastern parts of the species' range. Other sources of mortality may further diminish the northern long-eared bat's ability to persist in areas where populations are significantly reduced due to WNS.

Researchers have noted a progressive lessening of mortality rates at some hibernacula, but no clear evidence of resistant hibernating populations or decreased susceptibility of survivors to infection has been found (Langwig et al. 2010). There is currently no evidence of resistance to WNS among survivors, although some affected New York hibernacula continue to support relatively low numbers of bats several years into WNS exposure, and a few hibernacula have substantially lower mortality levels than most.

3.5.2 Other Threats

One of the first recognized threats to the Indiana bat was human disturbance and vandalism of hibernacula. Indiana bats are known to hibernate in large numbers, but this leaves them more vulnerable to disturbances during this sensitive time. Hibernating bats are susceptible to arousals from disturbance, which can deplete fat reserves and possibly lead to starvation (Thomas et al. 1990). Vandalism of hibernacula was one of the first problems to be addressed during the initial assessment of the species' decline, however when populations continued to decline, it became apparent that loss of summer habitat was also a significant threat (USFWS 2004). The conversion of forest to agricultural, urban or developed land is causing the greatest loss of habitat to the Indiana bat (USFWS 2009). The loss of and modification to the Indiana bat's winter habitat (i.e., cave and mine hibernacula) and summer habitat (i.e., forests) have been identified as long-standing and ongoing threats. A more extensive list of both historical and current threats to Indiana bats can be found in the *Recovery Plan for the Indiana Bat* (USFWS 1983), the 2007 Indiana Bat Draft Recovery Plan, and the *Indiana Bat (Myotis sodalis) 5-Year Review* (USFWS 2009).

The northern long-eared bat is facing similar threats to the Indiana bat due to the similarity in the two species' winter and summer habits. Disturbance during hibernation and loss of forest habitat may pose threats to the species also (USFWS 2014b). Some studies have found that northern long-eared bats are associated with mature, interior forest stands for roosting and foraging (Cryan et al. 2001, Yates and Muzika 2006) during the summer maternity season. The permanent or temporary removal of forested habitat may adversely affect the northern long-eared bat by reducing roosting, foraging and travel corridor habitat (USFWS 2014b). However, other studies have suggested that silvicultural practices such as prescribed burning are beneficial for northern long-eared bat roost habitat (Lacki et al. 2009) and that intensively managed forests are suitable, perhaps owing to the species' general flexibility in roosting requirements (Owen et al. 2002, 2003; Silvis et al. 2012). Retaining large diameter trees and snags (Sasse and Pekins 1996) and maintaining connectivity among forest patches (Owen et al. 2003) should help further minimize the effects of forest loss on northern long-eared bats.

4.0 IMPACT ASSESSMENT

This chapter identifies the Covered Activities proposed in the Permit Area that are likely to result in incidental take and quantifies the anticipated take levels.

Only activities that are likely to result in take are included as Covered Activities in this HCP. Wind turbine operation has the potential to result in take of the Covered Species in the form of mortality from collision with spinning turbines. Eight northern long-eared bat fatalities at wind energy facilities have been documented to date in USFWS Region 3, and six Indiana bat fatalities have been documented to date in the MRU (Seymour, USFWS, pers. comm. 2015; Pruitt and Okajima 2014). The fatalities documented by Pruitt and Okajima (2014) included one Indiana bat carcass found at the Project in mid-August 2015 (Good et al. 2016a).

The small number of Covered Species fatalities documented in many thousands of turbine searches indicate that documentation of northern long-eared bat and Indiana bat carcasses at wind energy facilities is a rare event. Because fatalities of the Covered Species are considered rare events, the USGS's Evidence of Absence (EoA) model (Huso et al. 2015) as modified by USGS with a reference prior (Dalthorp and Huso 2015) was used to predict take of the Covered Species and to quantify the uncertainty around those take predictions. The EoA model will also be used during compliance monitoring (Section 5.4.1) to assess take of the Covered Species and compliance with the requested ITP over its 27-year term.

This chapter also describes potential effects of the Project that are not expected to result in take, to assist the USFWS in expediting and satisfying the requirements of § 7 of the ESA process. According to § 7 of the ESA implementing regulations (50 CFR 402.02), "effects" refer to the direct and indirect effects of an action on the covered species or its critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the prior environmental conditions.

4.1 Indiana Bats

4.1.1 Overview

As described in Section 2.2 and in subsequent sections, the only Project activity expected to result in take of Indiana bats is Project operation. The Applicant predicts that normal operation of the Project may result in take of 516 Indiana bats over the 27-year permit duration. However, the Applicant will implement minimization measures to reduce the level of potential take for Indiana bats (Section 5.2.2). Based on the best available scientific information, the Applicant conservatively[13] predicts that incidental Indiana bat mortality from the Project will be reduced by at least 50% with minimization measures in place (see Section 4.1.3). Therefore, the predicted level of take and the requested amount of take to be authorized by the ITP over the 27-year permit duration is 258 Indiana bats (516 * 50% = 258). This predicted level of take is approximately 9.55 Indiana bats per year (see Section 4.1.1). Take will be estimated through compliance monitoring, and adaptive management will be used if necessary to ensure compliance with the requested ITP. Table 4.1 provides an overview of the predicted Indiana bat take from the Project's Covered Activities and the associated impact of take to be mitigated.

The Applicant will implement mitigation to offset the impact of take, including lost reproductive capacity of females that are taken by the Project. Assuming 75% of the take is attributed to females from a declining population, using the USFWS' *Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects, Version 7* (Indiana Bat REA Model; USFWS 2016g), the predicted lost reproductive capacity during the ITP term is 308 Indiana bats, resulting in a total predicted impact of take of 501 Indiana bats (see Section 4.1.5 for a discussion of the impact of the taking).

[13] Conservative means that actual Indiana bat mortality is likely to be lower than these estimates; curtailment studies from the FRWF in Benton County, Indiana, reported a 57% reduction in all bat fatality when turbines were feathered below 4.5 m/s (14.8 ft/s) and a 73% reduction in all bat fatality when turbines were feathered below 5.5 m/s (18.0 ft/s; Good et al. 2012). Curtailment is expected to be at least as effective for *Myotis* species in particular (see Section 4.1.3).

Table 4.1 Overview of the predicted Indiana bat take from the Headwaters Wind Farm Covered Activities and the associated impact of take to be mitigated

HCP Section	HCP Topic	Detail	Per Turbine	Per Year	Per ITP Term	Assumption
4.1.2	Predicted take without minimization	100 turbines; 27-year ITP term	0.1909	19.09	516	60th credible bound of predicted take rate
4.1.3	Predicted take with minimization	100 turbines; 27-year ITP term	0.0955	9.55	258	Minimization estimated at 50%
4.1.5	Predicted female take with minimization	100 turbines; 27-year ITP term	0.0716	7.16	193	3:1 ratio of females to males
4.1.5	Lost reproductive capacity	100 turbines; 27-year ITP term		11.41	308	From Indiana Bat REA Model
4.1.5	Loss of Indiana bats to be mitigated - females taken plus lost reproductive capacity	100 turbines; 27-year ITP term		18.55	501	From Indiana Bat REA Model
4.1.5	Annual reduction in population	Range-wide population		0.003%		Population estimate = 530,705 Indiana bats
		MRU population		0.008%		Population estimate = 243,402 Indiana bats
		WNS-MRU reduced population		0.080%		Population estimate = 24,340 Indiana bats
5.3.1	Target increase in Indiana bats during first 6-year mitigation increment	Years 1-6 of ITP term		18.55	111	

Collectively, female take and lost reproductive capacity of females represents the annual loss of approximately 18.55 Indiana bats per year over the 27-year ITP. This annual loss equates to an approximate 0.008% reduction in the MRU population (based on the size of the 2017 MRU population of 243,402), the Indiana bat population most likely to be impacted. Given that this loss represents a small percentage of the Indiana bat MRU population, and that mitigation implemented as part of this HCP is expected to fully offset the impacts of the taking, the Applicant does not expect the Project to have a significant impact on either the range-wide population or the MRU population of the species at the current population levels.

4.1.2 Predicted Indiana Bat Mortality without Minimization Measures

As described in Section 3.4.1, Indiana bats are assumed to occur in the Permit Area during the spring and fall migration periods (April 1 - May 15 and August 1 - October 15) and may be at risk of take during these seasons at all of the Project turbines. A subset of ten Project turbines may also present a measurable risk of take during the summer season (May 16 - July 31), as described in Section 3.4.1. The take prediction calculations were based on this seasonal and spatial analysis of risk to the Covered Species. The term "annual take" used throughout the rest of this section and the HCP refers to the amount of Indiana bat take predicted to occur or estimated to have occurred during the spring, summer, and fall periods in a given year.

The term "predicted" take refers to the amount of take that is projected to occur at the Project under implementation of the HCP; take is predicted for the purposes of establishing a requested take level to be authorized under the ITP. The term "estimated" take refers to the amount of take that is estimated to have occurred during a given monitoring period at the Project and is based on the monitoring data; take is estimated for the purposes of evaluating compliance with the requested ITP. In other words, take prediction refers to quantification of projected future take; take estimation refers to quantification of take that has already occurred.

Because Indiana bat mortality at wind energy facilities is a rare event, our ability to predict the level of Indiana bat take that may occur at the Project is constrained by a lack of data regardless of the predictive tool used. The lack of fatality monitoring data for the Project contributes to the uncertainty in the take prediction. The EoA model currently represents the best available model for estimating or predicting take of the Covered Species that also allows for quantification of the uncertainty in the take predictions produced. The EoA model used in this document is described in detail in Appendix B.

The EoA approach requires fatality monitoring data to inform the model outputs, and data from 2011, 2013, and 2014 monitoring at TRII were used to develop the Indiana bat take prediction. Because the Project turbines have not been managed under an operational strategy for which take of the Covered Species is expected (i.e., turbines are feathered under a cut-in speed of 6.9 m/s, recommended by the USFWS as avoidance measures for the Covered Species [Pruitt 2014]), there are no monitoring data available from the Project to inform the model outputs. Consequently, the EoA model was used to predict take of the Covered Species using data from the TRII wind facility, which is located approximately 97 km (60 mi) north of the Project in

Paulding County, Ohio, in a similar agricultural landscape. The TRII data were the most representative data available for prediction of Covered Species take at the Project, given the proximity of the two facilities and the similarity of land use and bat habitat across the facilities' sites.

Carcass search and bias trial data were available from the TRII facility for fall 2011 monitoring and spring through fall monitoring in 2014 and 2015 (Ritzert et al. 2012, Good et al. 2015). However, an Indiana bat carcass was discovered at the site on April 14, 2014, after which the TRII turbines were feathered at wind speeds below 6.9 m/s. Consequently, only the fall 2011 data and the spring 2014 data collected prior to April 14 (and none of the 2015 data) were appropriate for use in the EoA model due to these operational constraints. The carcass search and bias trial data from fall 2011 and spring 2014 (prior to the Indiana bat carcass discovery when turbines were operating under normal conditions) were used to develop the Indiana bat take prediction. The probability of detection for 2011 was adjusted to account for the fact that there were no spring searches, and the 2014 data were weighted to reflect that no take of the Covered Species was expected after cut-in wind speeds were increased to avoid future take of Indiana bats.

Carcass search data from monitoring of the five operational turbines in 2013 were also used to develop the Indiana bat take prediction, but the data were weighted to reflect that only five of 55 turbines at TRII were operational. Bias trial data were not available from 2013, so the 2014 bias trial data were used in lieu of 2013 bias trial data.

Annual searcher efficiency data, carcass persistence data, and search schedule were supplied to the single-site-single-year module of the EoA model, which calculates (among other things) the probability that a carcass on the site will be available to searchers and detected (g), based on searcher efficiency, carcass persistence, density weighted proportion of area searched, and search interval. The estimated value of g was supplied to a modified version of the multiple year module[14] of EoA with the annual weights to predict the distribution of the annual take rate. The seasonal distribution of take within a year was informed by the pattern of seasonal proportions of bat fatalities in the Midwest (USFWS 2016d).

The EoA model outputs for annual take rates at various credible bounds were developed using the data from TRII and adjusted to a per-turbine rate[15] for the purpose of scaling the take prediction to be appropriate for the Project. The TRII facility consists of 55 turbines with a nameplate capacity of approximately 99 MW, whereas the Project consists of 100 turbines with a nameplate capacity of approximately 200 MW. Therefore, it is reasonable to expect that the Project will take a greater number of Indiana bats (and bats in general) than TRII due to the

[14] The function was modified to provide the predicted annual take rate with credible bounds; the function supplied by USGS calculates these credible bounds but does not supply them as output.

[15] It is not statistically appropriate to scale take estimates (estimated numbers of bats killed) generated by the EoA model, but the EoA model also produces an estimated take rate (lambda; bats per facility per year) which can be scaled to a per-turbine basis or a multiple-year basis (D. Dalthorp, Forest and Rangeland Ecosystem Science Center, USGS, pers. comm. 2016).

presence of more turbines on the landscape. Therefore, the TRII annual Indiana bat take rates were scaled by a factor of 0.018 (1/55) to obtain a per-turbine annual Indiana bat take rate for the Project.

It is important when developing predicted take numbers for ITPs to use take rates that are high enough so that the take that actually occurs remains below the permitted number. This is because take occurs as a stochastic process, resulting in variance in the estimate of take. To support ITP compliance, the variance of the predicted take was quantified and used to assess the likelihood of the best estimate of take (the point estimate or 50% confidence level) exceeding the proposed take numbers for the ITP. When predicting take, there are two opportunities to choose credible bounds to ensure take compliance: the first is in the selection of per-turbine annual take rate, and the second is in the selection of predicted life-of-permit take. Schematically, the process is:

> Monitoring data → Estimated probability of detection (Section 3 of Appendix B) → Predicted annual per-turbine take rate distribution (Section 5 of Appendix B) → Scaled facility-wide life-of-permit take rate (Section 5 of Appendix B) → Predicted life of permit take distribution (Section 5 of Appendix B).

Credible bounds were chosen for the predicted annual per turbine take rate (λ_q) and the predicted life of permit take (M_q) using the scenario explorer in the EoA model, which simulates take and take estimation over the life of the permit to predict the probability of take exceedance based on actual take rates, permitted take numbers, detection probabilities for monitoring, and adaptive management.

The confidence in the take prediction is additionally influenced by the extent of the monitoring data available for use in the model. The TRII 2014 spring monitoring data (see Good et al. 2015) were limited to the April 1 through April 14 period (the period before the Indiana bat carcass was found). These 2014 data were included in the take rate estimate but the statistical properties of rare events and the way that the 2014 data were collected probably introduce an upwards bias in the take rate[16], meaning that the take estimates produced using these data are likely conservative.

Consequently, the Applicant used the 60th credible bound of the distribution of the scaled annual take rate prediction as a conservative prediction of Indiana bat take that is likely to occur at the Project. The 60th credible bound of the predicted take rate is λ_{60} = 0.1909 Indiana bat per turbine per year. The Applicant is comfortable that this take rate will not be exceeded, given the TRII monitoring data. The expected number of Indiana bats taken was obtained as the median of a Poisson distribution with a rate parameter of 515.82 bats (= 0.1909 bat per turbine per year * 100 turbines * 27 years): M_{50} = 516 (Table 4.1).

Although this value may overestimate the amount of take that could occur, it represents the level of predicted take for which the Applicant is comfortable the estimated take at the Project will not be exceeded, given the underlying take rate. Thus, the Applicant conservatively predicts that the average annual take rate of Indiana bats at the Project will be 19.09 Indiana bats per year without minimization measures in place. The cumulative predicted take (M_{50}) over the 27-year ITP term is 516 Indiana bats in the absence of minimization measures. Additional details of the EoA take prediction methods are provided in Appendix B.

4.1.3 Predicted Indiana Bat Mortality with Minimization Measures

The analysis presented in Section 4.1.2 represents Indiana bat mortality that can be expected under normal operating conditions. However, operational adjustments will be made as a condition of this HCP and the requested ITP to minimize the impacts of take of Indiana bats. Specifically, all turbine blades will be feathered below raised cut-in wind speeds of 3.5 m/s (11.5 ft/s; raised from the Project turbine's manufacturer's cut-in wind speed of 3.0 m/s [9.8 ft/s]) in the spring and 5.0 m/s in the fall, and a subset of 10 turbines with summer risk will feathered up to 5.0 m/s during the summer. (Table 4.3). These measures are expected to substantially reduce annual Indiana bat mortality at the Project. Feathering the remaining Project turbines below the

---

[16] The bias results from the way that the sample was obtained. Assume (as in the EoA model) that fatalities during a season are distributed as a $Poisson(\lambda)$ variable, where λ is the fatality rate. If the duration of a monitoring period is fixed in advance, the unbiased maximum likelihood estimate for λ is

$$\widehat{\lambda_{MLE}} = \frac{c}{d} \tag{1}$$

where c is the count of fatalities during the monitoring period and d is the duration of the monitoring period. However, if the monitoring period only lasts until the first carcass is observed (as at Timber Road in 2014) then the estimate is based on a waiting time until the first observation:

$$\widehat{\lambda_{waiting\ time}} = \frac{c}{t} = \frac{1}{t} \tag{2}$$

where t is the waiting time until the first carcass and the count, c, is necessarily 1 (because its observation terminated the monitoring process). For $\lambda_{waiting\ time}$ to be unbiased, we need

$$t = \frac{1}{\lambda} \tag{3}$$

but for a Poisson-distributed fatality process, the waiting time between carcasses, t, is known to be distributed as an $exponential(\lambda^{-1})$ variable. For an $exponential(\lambda^{-1})$ variable, the cumulative probability that the waiting time, t, will be less than λ^{-1} is 0.63. And because there is an inverse relationship between t and $\hat{\lambda}$, that means that there is a 63% chance to overestimate the fatality rate, λ, if the monitoring period is terminated after the first observed carcass.

manufacturer's rated cut-in speed in the summer is expected to additionally reduce all-bat mortality in general at the Project. Although there is uncertainty in the take prediction, the effectiveness of the proposed minimization measures at reducing take is supported by a substantial amount of research.

Several operational adjustment experiments have documented significant reductions in bat mortality that can be achieved by reducing or eliminating the rotation of turbine blades below cut-in wind speed, a strategy known as feathering, and/or increasing the wind speed at which turbines become operational, or their cut-in wind speed (Table 4.2). Mortality of bat species of the eastern and Midwestern US has been shown to have an inverse relationship with wind speed (Arnett et al. 2005); raising cut-in wind speeds and feathering turbine blades below cut-in during the night, during periods of low wind, and in the late-summer through early-fall can have a substantial effect on rates of bat mortality, as evidenced in the studies included in Table 4.2[17].

[17] Confidence intervals around the mean percent reductions in some studies overlapped and in those cases the reported reductions in bat mortality from curtailment were not significantly different from normally operating turbines or those curtailed at lower wind speeds. However, because fewer bat fatalities are generally found at turbines curtailed at higher wind speeds, there may have been insufficient power to detect a difference had there been one.

Table 4.2 Results from publicly-available curtailment effectiveness studies.

Study Name	Normal Cut-in Speed (m/s)	Treatment Cut-in Speed (m/s)	Mean Percent Reduction in Mortality	Mean Percent Reduction in Mortality Per Cut-in Speed	Source
FRWF, IN 2011[a]	3.5	3.5	36	36	Good et al. 2012
Summerview, Alberta	4.0	4.0	58	58	Baerwald et al. 2009
FRWF, IN 2011	3.5	4.5	57	52	Good et al. 2012
Anonymous Project (AN01), USFWS Region 3	3.5	4.5	47		Arnett et al. 2013
Casselman, PA 2008	3.5	5.0	82	61	Arnett et al. 2010
Casselman, PA 2009	3.5	5.0	72		Arnett et al. 2010
FRWF, IN 2010[b]	3.5	5.0	50		Good et al. 2011
Pinnacle, WV 2012[c]	3.0	5.0	47		Hein et al. 2013
Pinnacle, WV 2013	3.0	5.0	54		Hein et al. 2014
Summerview, Alberta	3.5	5.5	60	68	Baerwald et al. 2009
FRWF, IN 2011	4.0	5.5	73		Good et al. 2012
Anonymous Project (AN01), USFWS Region 3	3.5	5.5	72		Arnett et al. 2013
Sheffield, VT[d] 2009	4.0	6.0	60	60	Arnett et al. 2013
Casselman, PA 2008	3.5	6.5	82	77	Arnett et al. 2010
Casselman, PA 2009	3.5	6.5	72		Arnett et al. 2010
FRWF, IN 2010[b]	3.5	6.5	78		Good et al. 2011
Pinnacle, WV 2013	3.0	6.5	76		Hein et al. 2014

[a] Manufacturer's rated cut-in wind speed was not raised but turbines were feathered under normal cut-in wind speed.

[b] Study did not include feathering below cut-in wind speed.

[c] This effect was only found when an outlier (i.e., a night when seven fatalities were recovered from a 5.0 m/s all-night treatment turbine) was removed from the dataset.

[d] Raised cut-in wind speeds were applied only when temperatures were above 9.5 °C (49.1 °F).

All studies except Good et al. (2011) feathered turbines below cut-in wind speed. While different operational parameters of turbine types and models varied somewhat among studies, the results from these curtailment effectiveness studies can be used to estimate what can be expected from minimization measures that will be implemented as part of this HCP. Further, the results of these studies are important because they confirm that raising cut-in wind speeds and feathering turbine blades at low wind speeds can substantially reduce bat mortality.

Based on region and landscape characteristics, the research conducted at the FRWF in 2010 and 2011 is considered the most meaningful study for understanding reductions in bat mortality that are likely to be achieved by feathering all turbine blades below raised cut-in wind speeds of 3.5 m/s in the spring and 5.0 m/s in the fall, and feathering 10 turbines with summer risk to 5.0 m/s in the summer (the manufacturer's cut-in wind speed is 3.0 m/s). All bat fatalities were reduced by a mean of 50% when cut-in wind speed was increased from 3.5 m/s to 5.0 m/s (90%

confidence interval [CI] = 38% - 60%), and by 79% when cut-in wind speeds were increased to 6.5 m/s (21.3 ft/s; 90% CI = 71% - 85%; Good et al. 2011). Although cut-in wind speed was raised in the 2010 study, turbines were allowed to spin below cut-in (i.e., turbines were not feathered); the 2010 results may therefore underestimate the reduction in bat fatality that may be achieved by feathering turbines below these cut-in wind speeds.

Turbines in the 2011 study were feathered below cut-in wind speeds of 3.5, 4.5, and 5.5 m/s (11.5, 14.8, and 18.0 ft/s), which resulted in reductions of 36% (90% CI = 12% - 54%), 57% (90% CI = 39% - 70%), and 73% (90% CI = 60% - 83%) in bat mortality, respectively, compared with normally operating turbines (i.e., unfeathered below a cut-in wind speed of 3.5 m/s). Based on these results, between 57% and 73% reductions would have been achieved by feathering blades below a cut-in wind speed of 5.0 m/s in 2011 (Good et al. 2012). The average percent reduction for all studies that raised the cut-in wind speed to 5.0 m/s was 67%, which includes the results from FRWF 2010 that did not include feathering.

It is currently unclear if operational adjustments will be equally effective at reducing mortality among different species or species groups. Three species of long-distance migratory bats have been killed in the largest proportions at wind energy facilities in North America: the foliage-roosting hoary bat (*Lasiurus cinereus*) and eastern red bat (*Lasiurus borealis*), and the cavity-roosting silver-haired bat (*Lasionycteris noctivagans*) (Kunz et al. 2007, Arnett et al. 2008). Collectively, these species compose the vast majority of all bat fatalities documented at wind energy facilities (e.g., 75% of all documented bat fatalities at 19 wind energy facilities reviewed by Arnett et al. [2008]); consequently, these three species have provided the bulk of the all bat fatality data analyzed in the curtailment studies to date.

No curtailment studies have specifically analyzed the effectiveness of raised cut-in wind speeds in reducing *Myotis* fatality. However, it is plausible based on their morphology and flight behavior that smaller species of bats, such as *Myotis,* may be less active at higher wind speeds compared to larger species of bats that typically forage in more open habitats, and especially in the rotor-swept area of turbines. If this hypothesis is true, then effectiveness of curtailment for smaller bats as wind speeds increase would likely be less compared to the effectiveness for larger species. Conversely, if *Myotis* species are more active on low wind speed nights, and less active as wind speed increases (which is considered plausible given their small size and typical behavior of not foraging in large open areas, where winds would typically be greater) then feathering turbine blades to reduce blade movement at the lowest wind speeds would likely be most effective at reducing *Myotis* mortality.

Given the variability in the estimated reductions in bat mortality among studies (Table 4.2), and potential year-to-year variation, the Applicant estimates that feathering turbine blades below a raised cut-in wind speed of 3.5 m/s during the spring (all turbines) and 5.0 m/s during the summer (10 turbines) and fall migration season (all turbines) would reduce all bat mortality, including Indiana bat mortality, by at least 50% annually (Table 4.3). This is a conservative estimate based on the expectation that feathering turbines below 3.5 m/s in the spring will reduce bat mortality by approximately 36% (Good et al. 2012), when approximately 11%[18] of the take is expected to occur and that feathering turbines below 5.0 m/s in the summer (10 turbines) and fall (all turbines) will reduce bat mortality by approximately 61% (Arnett et al. 2010, Good et al. 2011, Hein et al. 2013, Hein et al. 2014), when approximately 89% of the take is expected to occur (11% x 36% + 61% x 89% = 58% reduction in the take rate).

A 50% reduction of the 60th credible bound of the predicted take yields a scaled take rate (λ_{60}) of 0.0955 bat per turbine per year and results in a minimized take prediction of about 9.55 Indiana bats per year. The median of the cumulative minimized take prediction (M_{50}) over the 27-year ITP term is 258 Indiana bats. The Applicant is comfortable that this prediction for the ITP term will not be exceeded based on the 60th credible bound of the annual take rate distribution.

Table 4.3 Operational minimization plan for the Headwaters Wind Farm.

Season	**Turbines**	**Time of Day**	**Cut-in Speed**	**Feathering Below Cut-in[1]?**	**Temperature Threshold[2]**
Spring (April 1 - May 15)	All	0.5 hour before sunset to 0.5 hour after sunrise	3.5 m/s	Yes	10 °C
Summer (May 16 - July 31)	12024[3], 12025[3], 18095[3], 18096[3], 17077[3], 14041[3], 14039[3], 14040[3], 16071[3], 16070[3]	0.5 hour before sunset to 0.5 hour after sunrise	5.0 m/s	Yes	10 °C
Summer (May 16 – July 31)	All (except the ten at 5.0m/s)	0.5 hour before sunset to 0.5 hour after sunrise	3.0 m/s	Yes	No
Fall (August 1 – October 15)	All	0.5 hour before sunset to 0.5 hour after sunrise	5.0 m/s	Yes	10 °C
Winter (October 16 – March 31)	All	Normal turbine operation			

[1] Feathering means that turbine blades will be pitched into the wind such that they spin at less than one rotation per minute.

[2] Turbines will be feathered below cut-in when temperatures are above the threshold.

[3] Turbines determined to have summer risk to the Covered Species (Sections 3.4.1 and 3.4.2).

[18] Seasonal distribution based on the seasonal distribution of *Myotis* fatalities from 41 studies conducted in the eastern and Midwestern US that conducted monitoring during the entire Indiana bat active period (USFWS 2016d), under the assumption that most take of Indiana bats from the Project will be distributed across the spring and fall seasons (summer take is expected to occur at a subset of 10 Project turbines).

4.1.4 Proposed Indiana Bat Take Limit

No Indiana bat take is expected to occur during maintenance, decommissioning, or mitigation activities (see Sections 2.1.2, 2.1.3, and 2.2.2). The only Project activity expected to result in take is operation of the turbines. The Applicant requests a take limit of 258 Indiana bats over the 27-year term of the ITP, based on the predicted annual Project take of 9.55 Indiana bats per year.

The Applicant will conduct compliance monitoring and implement adaptive management if necessary to ensure that the cumulative take estimated from monitoring is equal to or less than the ITP take limit.

4.1.5 Impacts of the Taking of Indiana Bats

Determining the significance of potential take on a species or population requires an understanding of population demographics, and in particular the annual survival and mortality rates, as well as a definition of the population being impacted. However, loss of a female would have a greater impact to the overall population than loss of a male, because it results in lost reproductive potential. To understand the biological impact of the Project take on Indiana bat populations, therefore, it is necessary to estimate what proportion of the Indiana bats affected by take are likely to be reproductive females.

All Indiana bats affected by take during the summer season are expected to be females from maternity colonies near the Project. It is unclear based on available scientific information if there are sex-related factors that might influence collision risk during the spring and fall migration seasons. Few empirical data are available on the sex ratios of *Myotis* bats found in mortality monitoring studies, or for all bat species generally, partly because many carcasses cannot be identified to age or sex due to decomposition and scavenging by insects. The sex of bat carcasses found was reported in 50 publicly available mortality monitoring studies in the eastern and Midwestern United States and Canada.[19] Among 5,860 carcasses of all bat species, 22%, 41%, and 37% were identified as females, males, and unknown sex, respectively. For *Myotis* species specifically, among 460 *Myotis* carcasses, 18%, 40%, and 42% were identified as females, males, and unknown sex, respectively. Since such a large percentage of bats could not be identified to either sex (42%), it was unclear whether or not males made up the majority of fatalities. If unidentified bats were divided equally among the two sexes, the ratio of females to males would have been skewed towards males (39% females and 61% males).

[19] Barton I and II, Blue Sky Green Field, Buffalo Mountain (2000-2003), Buffalo Mountain (2005), Buffalo Ridge (2000), Buffalo Ridge (Phase II; 2001/Lake Benton I), Buffalo Ridge (Phase III; 2001/Lake Benton II), Buffalo Ridge I (2010), Buffalo Ridge II (2011), Casselman (2008), Casselman (2009), Cohocton/Dutch Hill (2009), Cohocton/Dutch Hills (2010), Criterion (2011), Crystal Lake II, Elm Creek, Elm Creek II, Fowler I, II, III (2010), Fowler I, II, III (2011), Grand Ridge I, Lakefield Wind, Lempster (2009), Lempster (2010), Locust Ridge II (2009), Locust Ridge II (2010), Mars Hill (2008), Moraine II, Mount Storm (2009), Mount Storm (2010), Mount Storm (2011), Mount Storm (Fall 2008), Munnsville (2008), Noble Bliss (2009), Noble Clinton (2009), Noble Ellenburg (2009), NPPD Ainsworth, Pioneer Prairie I (Phase II), Prairie Winds ND1 (Minot), Prairie Winds ND1 (Minot) (2011), Prairie Winds SD1 (Crow Lake), Prince Wind Farm (2006), Rugby, Sheldon (2010), Sheldon (2011), Stetson Mountain I (2011), Stetson Mountain II (2010), Wessington Springs (2009), Wessington Springs (2010), Winnebago, Wolfe Island Report 2 (July-December 2009). (see Appendix C).

However, the geographic location of the Project indicates that the Indiana bats migrating through the Permit Area in the spring and fall may be mostly females. Female Indiana bats disperse from hibernacula to join summer maternity colonies, while male Indiana bats typically remain closer to hibernacula throughout the summer (Gardner and Cook 2002, Whitaker et al. 2002). The closest known Indiana bat hibernaculum to the Project is approximately 38 km (24 mi) away (Lewisburg Mine in Preble County, Ohio). Therefore, if collision risk is generally equal for both sexes, the majority of Indiana bat fatalities at the Project are likely to be female bats due to their more frequent occurrence within the Permit Area during migration. Adding support to this is the fact that all but two of the eight Indiana bat fatalities documented to date have been females (six females, one male, and one unknown sex; USFWS 2011a, 2011c, 2012a, 2012b; Pruitt and Okajima 2014).

If we expect a number of conditions: (1) that there are more female adults in the spring and fall migratory populations (as noted, males are more likely to remain in the vicinity of their hibernacula throughout the summer [Gardner and Cook 2002, Whitaker and Brack 2002], although some have been documented migrating over 400 km [249 mi] from hibernacula in southern Indiana and Kentucky [Kurta and Murray 2002]), (2) that the fall migrating juveniles occur at a 1:1 sex ratio, and (3) that all take during the summer will affect females, then a 3:1 ratio of female Indiana bats to male Indiana bats at the Project is a reasonable assumption. Therefore, approximately 75% of the Indiana bats that are potentially likely to be taken by the Project are expected to be reproductive females. This ratio may be an overestimate of the proportion of take attributable to female bats, but based on available data from the 50 publicly available mortality monitoring studies at wind energy facilities in the eastern and Midwestern US and Canada (see Appendix C), it represents a conservative approach for assessing the impact of take on the population.

Based on data from genetic, banding, and telemetry studies, it is highly likely that Indiana bats migrating through the Permit Area are part of the MRU population (USFWS 2007a). Thus, the impacts of the taking are evaluated as they pertain to the MRU population in the following section. Also, impacts are evaluated at the range-wide population level (i.e., over the total range of the species).

The Applicant predicts that a total of 9.55 Indiana bats will be taken each year during the 27-year ITP term. Approximately 75% of the incidental take is expected to be attributed to females, which would result in an annual female take of 7.16 bats. Using the USFWS' Indiana Bat REA Model and a declining population, the total predicted lost reproductive capacity during the ITP term is 308 female pups, resulting in a total predicted impact of 501 Indiana bats (258 Indiana bats [total take] * 75% = 193 Indiana bats [total female take] + 308 Indiana bats [lost reproduction] = 501 Indiana bats [impact of take]) over the 27-year ITP term.

Collectively, predicted female take and lost reproductive capacity of females represents the annual loss at the Project of approximately 18.55 Indiana bats per year over the 27-year ITP term. Mitigation actions, therefore, will have a target increase of 501 Indiana bats, or 18.55 bats per year to account for this lost reproductive capacity.

The loss of bats and reproductive capacity from maternity colonies may reduce the productivity of the colony as a reproductive unit and, if losses are great enough, could potentially threaten the persistence of the colony on the landscape. The loss of bats from hibernacula populations may diminish the abundance of the population and, if losses are great enough, could potentially affect the growth rate (lambda) of the hibernating population. However, because take from the Project is expected to consist of individual bats migrating from various hibernacula and various maternity colonies, take is not likely to have a concentrated or frequent impact on any single maternity colony or hibernaculum.

The average annual loss of 18.55 Indiana bats equates to an approximate 0.008% reduction of the 2017 population of 243,402 Indiana bats in the MRU (USFWS 2017), the Indiana bat population most likely to be impacted. Even if the MRU population of Indiana bats were reduced by 90% as a result of WNS, the loss of 18.55 Indiana bats per year (see Section 4.1.1) represents only 0.08% of the WNS- reduced population of 24,340 Indiana bats. The loss to the range-wide population would be 0.003%, based on the 2017 estimated range-wide population size of 530,705 Indiana bats (USFWS 2017).

These losses represent small fractions of the MRU and range-wide Indiana bat populations. Given the expected minimal impact of Project take on overall population levels, and because mitigation actions are expected to fully offset the impacts of Project take as well, the Applicant does not expect the Project to have a significant impact on the MRU or range-wide population of the species at the current population levels. If the population of Indiana bats in the MRU becomes substantially reduced as a result of WNS or other factors, the Applicant will take corresponding action as described in Chapter 8.

4.2 Northern Long-Eared Bats

4.2.1 Overview

As described for Indiana bats, the only Project activity expected to result in take of northern long-eared bats is Project operation. The Applicant predicts that normal operation of the Project may result in take of 136 northern long-eared bats over the 27-year permit duration. However, the Applicant will implement minimization measures to reduce the level of potential take for northern long-eared bats (Section 5.2.2). Based on the best available scientific information, the Applicant conservatively[20] estimates that incidental northern long-eared bat mortality from the Project's Covered Activities will be reduced by at least 50% with minimization measures in place (see Section 4.1.3). Therefore, the predicted level of take and the requested amount of take to be authorized by the ITP over the life of the Project is 68 northern long-eared bats (136 * 50% =

[20] Conservative means that actual northern long-eared bat mortality is likely to be lower than these estimates; curtailment studies from the FRWF reported a 57% reduction in all bat fatality when turbines were feathered below 4.5 m/s and a 73% reduction in all bat fatality when turbines were feathered below 5.5 m/s (Good et al. 2012). Curtailment is expected to be at least as effective for *Myotis* species in particular (see Section 4.1.3)

68). This estimated level of take is approximately 2.53 northern long-eared bats per year. Take will be estimated through compliance monitoring and adaptive management will be used to ensure compliance with the ITP. Table 4.4 provides an overview of the predicted northern long-eared bat take from the Project's Covered Activities and the associated impact of take to be mitigated.

The Applicant will implement mitigation to offset the impact of take, including lost reproductive capacity of females that are taken by the Project. Assuming 50% of the take is attributed to females from a declining population and using the USFWS' *Region 3 Northern Long-Eared Bat Resource Equivalency Analysis Model for Wind Energy Projects, Version 1* (Northern Long-Eared Bat REA Model; USFWS 2016h), the predicted lost reproductive capacity during the ITP term is 54 northern long-eared bats, resulting in a total predicted impact from the Project's Covered Activities of 88 northern long-eared bats during the ITP term (see Section 4.2.5 for a discussion of the impact of the taking).

Table 4.4 Overview of the predicted northern long-eared bat take from the Headwaters Wind Farm Covered Activities and the associated impact of take to be mitigated

HCP Section	HCP Topic	Detail	Per Turbine	Per Year	Per ITP Term	Assumption
4.2.2	Predicted take without minimization	100 turbines; 27-year ITP term	0.0506	5.06	136	60th credible bound of predicted take rate
4.2.3	Predicted take with minimization	100 turbines; 27-year ITP term	0.0253	2.53	68	Minimization estimated at 50%
4.2.5	Predicted female take with minimization	100 turbines; 27-year ITP term	0.0126	1.26	34	1:1 ratio of females to males
4.2.5	Lost reproductive capacity	100 turbines; 27-year ITP term		2.00	54	From Northern Long-Eared Bat REA Model
4.2.5	Loss of northern long-eared bats to be mitigated - females taken plus lost reproductive capacity	100 turbines; 27-year ITP term		3.26	88	From Northern Long-Eared Bat REA Model
4.2.5	Annual reduction in population	Range-wide population		0.00005%		Population estimate = 6,546,718 northern long-eared bats
		Indiana population		0.002%		Population estimate = 127,842 northern long-eared bats
		WNS-reduced Indiana population		0.125%		Population estimate = 2,557 northern long-eared bats
5.3.1	Target increase in northern long-eared bats during first 6-year mitigation increment	Years 1-6 of ITP term		3.26	20	

Collectively, female take and lost reproductive capacity of females represents the annual loss of approximately 3.26 northern long-eared bats per year over the 27-year ITP. Based on available information, this loss represents a small percentage of the estimated northern long-eared bat population in the Midwest and Indiana, and mitigation implemented as part of this HCP is expected to fully offset the impacts of the taking. Thus, the Applicant does not expect the Project to have a significant impact on northern long-eared bats at current or future population levels.

4.2.2 Predicted Northern Long-Eared Bat Mortality without Minimization Measures

As described in Section 3.4.2, northern long-eared bats are assumed to occur in the Permit Area during the spring and fall migration periods (April 1-May 15 and August 1-October 15) and may be at risk of take during these seasons at all of the Project turbines. A subset of ten Project turbines may also present a measurable risk of take during the summer season (May 16-July 31), as described in Section 3.4.2. The take prediction calculations were based on this seasonal and spatial analysis of risk to the Covered Species. The term “annual take” used throughout the rest of this section and the HCP refers to the amount of northern long-eared bat take predicted to occur or estimated to have occurred during the spring, summer, and fall periods in a given year. As explained for Indiana bats, take “prediction” refers to quantification of projected future take; take “estimation” refers to quantification of take that has already occurred.

As with Indiana bat fatalities, northern long-eared bat fatalities at wind energy facilities are rare events, a reality which constrains our ability to predict the level of northern long-eared bat take that may occur at the Project regardless of the predictive tool used. Procedures to predict take of northern long-eared bat were broadly similar to those used to predict take of Indiana bats (Section 4.1.2); data from fall 2011, 2013, and spring 2014 monitoring at the TRII facility were used as input data in the EoA model, since appropriate Project-specific data do not exist. The annual take rate distribution using TRII data was again scaled to a per-turbine rate, as described in Section 4.1.2. The lack of fatality monitoring data for the Project contributes to the uncertainty in the take prediction. The EoA model currently represents the best available model for estimating and predicting take of the Covered Species.

As with the Indiana bat take prediction, the Applicant used the 60^{th} credible bound of the predicted take rate as a conservative prediction of the take rate for northern long-eared bat that may occur at the Project. The 60^{th} credible bound of the predicted take rate is $\lambda_{60} = 0.0506$ northern long-eared bat per turbine per year. The Applicant is comfortable that this scaled take rate will not be exceeded, given the TRII monitoring data. The expected number of northern long- eared bats taken was predicted as the median of a Poisson distribution with a rate parameter of 136.39 bats (= 0.0506 bat per turbine per year * 100 turbines * 27 years): $M_{50} = 136$ (Table 4.4).

Although this value may overestimate the amount of take that could occur, it represents the level of predicted take for which the Applicant is comfortable the estimated take at the Project will not be exceeded, given the underlying take rate. Thus, the Applicant conservatively predicts that, without minimization measures in place, the average take rate of northern long-eared bats at the Project will be 5.06, with a cumulative predicted take (M_{50}) over the 27-year ITP term of 136 northern long-eared bats.

4.2.3 Predicted Northern Long-Eared Bat Mortality with Minimization Measures

The analysis presented in Section 4.2.2 represents northern long-eared bat mortality that can be expected under normal operating conditions. However, specific operational adjustments will be made as a condition of this HCP and the requested ITP to minimize the impacts of take of northern long-eared bats. These measures are expected to substantially reduce annual northern long-eared bat mortality at the Project. As described for Indiana bat take minimization, although there is uncertainty in the take prediction, the effectiveness of the proposed minimization measures at reducing take is supported by a substantial amount of research.

As detailed in Section 4.1.3, several recent operational adjustment experiments have documented significant reductions in bat mortality that can be achieved by feathering turbines below their cut-in speed and/or increasing their cut-in wind speed (Table 4.2). Bat mortality has been shown to have an inverse relationship with wind speed (Arnett et al. 2005); raising cut-in wind speeds and feathering turbine blades below cut-in during periods of low wind can have a significant effect on rates of bat mortality, as evidenced in the studies included in Table 4.2 and detailed in Section 4.1.3.

Given the variability in the estimated reductions in bat mortality among studies (Table 4.2), and potential year-to-year variation, the Applicant estimates that feathering all turbine blades below a raised cut-in wind speed of 3.5 m/s (raised from the manufacturer's cut-in wind speed of 3.0 m/s) during the spring and 5.0 m/s during the fall migration season and 5.0 m/s during the summer at 10 turbines would reduce all bat mortality, including northern long-eared bat mortality, by at least 50% annually (Table 4.3). Feathering the remaining Project turbines below the manufacturer's rated cut-in speed in the summer is expected to additionally reduce all-bat mortality in general at the Project. A 50% reduction of the 60^{th} credible bound of the predicted take rate yields a scaled take rate (λ_{60}) of 0.0253 bat per turbine per year and median of minimized life-of- permit take (M_{50}) of 68 northern long-eared bats. The average annual take rate over the 27-year ITP term is expected to be about 2.53 northern long-eared bats per year.

4.2.4 Proposed Northern Long-Eared Bat Take Limit

No northern long-eared bat take is expected to occur during maintenance, decommissioning, or mitigation activities (see Sections 2.1.2, 2.1.3, and 2.2.2). The only Project activity expected to result in take is operation of the turbines. The Applicant requests a take limit of 68 northern long-eared bats over the 27-year ITP term.

The Applicant will conduct compliance monitoring and implement adaptive management if necessary to ensure the cumulative take estimated from monitoring is equal to or less than the ITP take limit.

4.2.5 Impacts of the Taking of Northern Long-Eared Bats

Determining the significance of potential take on a species or population requires an understanding of population demographics, and in particular the annual survival and mortality rates, as well as a definition of the population being impacted. However, loss of a female would have a greater impact to the overall population than loss of a male, because it results in lost reproductive potential. To understand the biological impact of the Project take on northern long-eared bat populations, therefore, it is necessary to estimate what proportion of the bats affected by take is likely to be reproductive females.

Prior to the onset of WNS, information on the sex of carcasses was not collected in most cases. Therefore, patterns related to sex of carcasses cannot be inferred from post-construction monitoring data. However, all northern long-eared bats affected by take during the summer season are expected to be females from maternity colonies near the Project. As discussed in Section 4.1.5, it is unclear if there are sex-related factors that influence collision risk during the spring and fall migration seasons. As explained in Section 4.1.5, if unsexed bat carcasses were divided equally among the two sexes and added to bat carcasses of known sex, the ratio of females to males would be skewed toward males (39% females and 61% males). This result is similar to that reported in Pennsylvania for 16 wind energy facilities monitored from 2007 to 2011, where 2,820 bat carcasses were collected, of which 23% were cave-dwelling species including *Myotis* species (Taucher et al. 2012). For bats of all species (sex was not reported by species or species group), male bats were found more often than female bats (59% male: 29% female; 12% were of unknown sex). Similarly, Arnett et al. (2008) reviewed data from 21 fatality studies conducted from 1996 to 2006 at 19 wind facilities in five US regions and one Canadian province and found fatalities included more males for the four most commonly killed species (hoary bats, eastern red bats, silver-haired bats, and tri-colored bat). However, the authors did not report on sex ratios of *Myotis* bats specifically, or for cave-dwelling bats as a group.

Unlike Indiana bat hibernacula, the locations of most northern long-eared bat hibernacula remain undocumented, partly due to the species' common status prior to the impact of WNS, and partly due to the species' use of smaller hibernacula that are more dispersed on the landscape. Although the Project is not located near any known northern long-eared bat hibernacula, male and female northern long-eared bats are assumed equally likely to occur within the Permit Area, because data that would prove otherwise are lacking. Therefore, the Applicant assumes that 50% of the take at the Project will be attributed to reproductive females. This ratio may be an overestimate, given the evidence that male bats may be at higher risk of collision with wind turbines, but it represents a conservative[21] approach for assessing the impact of take on the population.

The Applicant predicts that approximately 2.53 northern long-eared bats will be taken each year during the 27-year ITP term (see Section 4.2.1). Approximately 50% of the incidental take is

[21] Conservative means actual proportion of females to males in taken bats may be less (less than 1:1) and consequently the impact of take on the population may be less than assessed in this analysis and compensated for by the mitigation.

expected to be attributed to females, which would result in an annual female take of 1.26. Using the USFWS' Northern Long-Eared Bat REA Model, and assuming a declining population, the total predicted lost reproductive capacity during the ITP term is 54 northern long-eared bats, resulting in a total estimated impact of 88 northern long-eared bats (68 northern long-eared bats [total take] * 50% = 34 northern long-eared bats [total female take] + 54 northern long-eared bats [lost reproduction] = 88 northern long-eared bats [impact of take]) during the 27-year ITP term.

Collectively, female take and lost reproductive capacity of females represents the annual loss at the Project of approximately 3.26 northern long-eared bats per year over the 27-year ITP term. Mitigation actions, therefore, will have a target increase of 88 northern long-eared bats to account for this lost reproductive capacity.

The loss of bats and reproductive capacity from maternity colonies may reduce the productivity of the colony as a reproductive unit and, if losses are great enough, could potentially threaten the persistence of the colony on the landscape. The loss of bats from hibernacula populations may diminish the abundance of the population and, if losses are great enough, could potentially affect the growth rate (lambda) of the hibernating population. However, because take from the Project is expected to consist of individual bats migrating from various hibernacula and various maternity colonies, take is not likely to have a concentrated or frequent impact on any single maternity colony or hibernaculum.

There are limited data available to evaluate the population-level impact of this take due to the northern long-eared bat's tendency to hibernate individually or in small groups and hidden in crevices, making it difficult to obtain accurate counts of wintering individuals. However, the annual loss of 3.26 female northern long-eared bats equates to an approximate 0.00005% of the estimated range-wide northern long-eared bat population of 6,546,718 individuals (USFWS 2016e).

The Indiana population of northern long-eared bats is the population most likely to be affected by the Project, given the species' relatively short migration distances (refer to Section 3.3.5). The loss of 3.26 northern long-eared bats per year represents 0.003% of the Indiana population of 127,842 northern long-eared bats (USFWS 2016e). Even if this population were reduced by 98% as a result of WNS (the population loss reported in the northeast by Turner et al. 2011), the loss of 3.26 female northern long-eared bats per year represents only 0.127% of the WNS-reduced population of 2,557 bats. This loss represents a small fraction of the range-wide estimated population of northern long-eared bats. Because this loss represents a small percentage of the estimated northern long-eared bat population in Indiana, and mitigation implemented as part of this HCP is expected to fully offset the impacts of the Project take, the Applicant does not expect the Project to have a significant impact on northern long-eared bats at current or future population levels. However, if the population of northern long-eared bats becomes even more reduced as a result of WNS or other factors, the Applicant will take corresponding action as described in Chapter 8.

5.0 MINIMIZATION, MITIGATION, AND MONITORING PLAN

Consistent with ESA § 10(a)(2)(B), the Applicant plans to “minimize and mitigate the impact” of take of the Covered Species from Covered Activities “to the maximum extent practicable”. Monitoring will be implemented as part of this HCP to provide the information necessary to assess ITP compliance, evaluate Project impacts, and verify progress towards meeting the biological goals and objectives. The monitoring program will include both take limit compliance and mitigation effectiveness monitoring. Adaptive management will be used to address uncertainties identified in the HCP, including the accuracy of the predicted take estimate and the effectiveness of proposed minimization and mitigation measures.

5.1 Biological Goals and Objectives

An HCP’s biological goals “broadly describe the desired future conditions of an HCP in succinct statements” and each biological goal “steps down to one or more objectives that define how to achieve these conditions in measureable terms” (USFWS and NMFS 2016). The biological goals and objectives “lay the foundation from which all conservation activities arise” (USFWS and NMFS 2016). The biological goals and objectives of this HCP were designed to be SMART: specific, measurable, achievable, realistic, and timely. While measures to conserve or recover an endangered or threatened species are not required under § 10 of the ESA, the biological goals and objectives of this HCP are consistent with actions to promote the recovery of the Indiana bat, as identified in the 2007 Draft Indiana Bat Recovery Plan. The biological goals and objectives of this HCP also focus on conservation of the northern long- eared bat.

Goal 1: Minimize the impacts of the incidental taking of Covered Species bats that occur within the Permit Area.

Objective to achieve Goal 1: Implement an operational strategy in each permit year that will decrease Covered Species’ fatality rates by at least 50% compared to the predicted rates without minimization (Sections 4.1 and 4.2).

Goal 2: Fully offset the Project’s impact of the taking by protecting vulnerable habitat for the Covered Species.

Objective to achieve Goal 2: Implement a cave gating project at a Priority 2 hibernaculum to protect hibernating Indiana bats and possibly northern long-eared bats, and/or protect the number of summer/swarming habitat acres within the range of known maternity colonies and/or hibernacula that are required in the REA model and swarming guidance to offset the impact of the take.

Goal 3: Increase understanding of the factors that contribute to the Covered Species’ increased risk at wind energy facilities.

Objective to achieve Goal 3: Conduct a mortality monitoring program with the primary goal of ensuring compliance with the requested ITP, and a secondary goal of increasing scientific understanding of the uncertainty in measuring rare bat fatalities at wind turbines. Specifically, the monitoring program will be designed and implemented to increase understanding of the likelihood of detecting Covered Species carcasses and to evaluate the actual level of Covered Species take that is occurring at the Project.

Goal 4: Optimize electrical output of the Project to realize the environmental benefit of wind energy. Specifically, increased generation from wind energy facilities has the potential to offset demand for other energy generation technologies that produce carbon emissions that have been shown to contribute to global climate change, identified as a potential risk to both of the Covered Species (USFWS 2007a; 80 FR 17974).

Objective to achieve Goal 4: Implement an operational strategy at the Project in each permit year that maximizes output of non-carbon-emitting, renewable energy and also meets Goal 1, minimization of the impacts of incidental take of the Covered Species.

Measures that will be used to meet these goals and objectives, and the criteria that will be used to evaluate their success, are described in detail in the following sections.

5.2 Measures to Avoid and Minimize the Impact of the Taking

5.2.1 Avoidance through Project Design and Planning

Although much of the Project development process occurred prior to 2012, the Applicant followed a tiered evaluation process similar to the process outlined in the *USFWS Land-Based Wind Energy Guidelines* (USFWS 2012c) to assess potential impacts of the Project. Mist-netting surveys conducted in 2010 indicated the summer presence of Indiana bats and northern long-eared bats at the original site selected for the Project. After these surveys were conducted, the Applicant relocated the Project approximately 10 km to the east of the former boundary due to development considerations. Additional mist-netting in the relocated Permit Area in 2013 (Good et al. 2014a) did not detect Indiana bats or northern long-eared bats on-site, and the Project as proposed is situated in a primarily agricultural landscape.

No trees were cleared outside of the winter season during Project construction and Project commissioning occurred outside of the fall migration season (August 1 – October 15, 2014). These measures avoided take of the Covered Species during Project construction.

Following the useful life of the Project facilities and infrastructure, the Applicant has the option to recommission the Project or decommission the assets. If the Applicant elects to decommission the Project, actions associated with decommissioning are not likely to take the Covered Species because the same seasonal and timing restrictions for operation of turbines during commissioning will be applied (i.e., seasonal or time of day avoidance). Decommissioning of the Project also minimizes long-term impacts (when compared with re- commissioning or repowering the Project) by removing turbines from the site and restoring the site to the pre-existing land use and vegetation communities.

5.2.2 Minimization through Project Operations

The Applicant will minimize potential impacts of take of the Covered Species from the Project's Covered Activities by implementing seasonal turbine operational adjustments. For the term of the requested ITP, the Applicant will: 1) raise the cut-in wind speed from 3.0 m/s to 3.5 m/s during the spring migration season and to 5.0 m/s during the fall migration season at all turbines and to 5.0 m/s during the summer at the subset of 10 turbines with summer risk(as discussed in Sections 4.1.2 and 4.2.2, these are the periods of expected risk for Indiana bats and northern long-eared bats at the Project); and 2) adjust the turbine operational parameters so that the rotation of the turbine rotors below cut-in wind speed is minimized (the blades are feathered). Increasing cut-in wind speed and feathering of turbine blades below cut-in wind speed will be implemented on a nightly basis from a half hour before sunset to a half hour after sunrise, adjusted for sunset/sunrise times weekly, from April 1 - May 15, May 16 - July 31 (10 turbines), and August 1 - October 15, annually. These measures are summarized in Table 4.3.

Turbines will be monitored and controlled based on wind speed on an individual basis (i.e., the entire Project will not alter cut-in wind speed of all turbines at the same time, rather operational changes will be based on wind speed conditions specific to each turbine)[22]. Based on the Project's turbine operation algorithms, turbines will begin operating under normal conditions when the 2-minute minimum wind speed is above the cut-in wind speed (3.5 m/s in spring, 5.0 m/s in summer and fall); turbines will be feathered again if the 5- minute maximum wind speed goes below the cut-in wind speed during the course of the night.

The only exception to feathering turbines below a cut-in wind speed of 3.5 m/s in spring or 5.0 m/s in summer (10 turbines) and fall would occur on nights when temperatures are below 10°C in each season (refer to Sections 3.2.2.5 and 3.3.2.5 for justification of temperature threshold). Turbines will be allowed to operate at full capacity below these temperatures. Turbines will be monitored and controlled based on temperature on an individual basis (i.e., the Project will not alter cut-in wind speed of all turbines at the same time, rather operational changes will be based on temperature conditions specific to each turbine). Turbines will begin operating under normal conditions when the 5-minute rolling average temperature drops below 10°C; feathering will be resumed if the 5-minute rolling average temperature goes above 10°C during the course of the night.

Given the relatively small proportion of time that temperatures are expected to be below 10°C during fall (when most bat mortality and most take of the Covered Species is expected to occur),

[22] Each Project turbine is equipped with two well-calibrated wind sensors; if one sensor fails, the turbine will usually send out a warning signal. Additionally, the Project runs automated and manual power curve algorithms periodically and any issues with the wind sensors would be reflected in a turbine's power curve. Lastly, technicians inspect Project turbines on a regular schedule, and if sensors are not functioning correctly, the sensors are replaced during the inspection.

and the relatively large proportion of fatalities that occurred above 10°C at TRII and FRWF during fall (Sections 3.2.2.5 and 3.3.2.5), feathering turbine blades below 3.5 m/s in spring and 5.0 m/s in summer (10 turbines) and fall when temperatures are above this temperature threshold is expected to adequately minimize risk to bats and achieve at least an overall 50% reduction in all bat mortality, based on operational adjustment studies described in Table 4.2.

In addition to these minimization measures, the Applicant will implement an adaptive management plan that includes raising cut-in wind speeds in 0.5-m/s (1.6-ft/s) increments, if needed, to assure compliance with the authorized annual take threshold. The adaptive management plan will also allow cut-in wind speeds to be lowered in 0.5-m/s increments if they were previously raised in response to an adaptive management threshold being met, and if the post-construction monitoring indicates the lower speed will result in take below the annual adaptive management threshold.

5.3 Measures to Mitigate the Impact of the Taking

As described above, the Applicant will implement operational practices that are expected to reduce mortality of the Covered Species, and thus minimize the impact of take. However, some incidental mortality is still expected to occur. As described in Chapter 4, the predicted level of Indiana bat and northern long-eared bat mortality with minimization measures in place is expected to be less than or equal to 258 Indiana bats and 68 northern long-eared bats over the 27-year ITP term. To mitigate for the impacts of this take, the Applicant will coordinate and provide funding for mitigation that will result in a gain in female Indiana bats and northern long-eared bats by at least 501 and 88 females, respectively, as a result of mitigation projects, as determined using the USFWS REA models specific to each Covered Species (USFWS 2016g, USFWS 2016h).

The 2007 Draft Indiana Bat Recovery Plan includes proposed recovery actions based on four broad categories: 1) population monitoring actions; 2) conservation and management of habitat (hibernacula, swarming, summer); 3) further research essential for the species' recovery; and 4) public education and outreach. The 2007 Draft Indiana Bat Recovery Plan identifies Priority 1 actions that are most important and effective for recovery or reclassification of the Indiana bat, namely, hibernacula- and summer habitat-related recovery actions as well as those "that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future" (USFWS 2007a). Because a recovery plan has not yet been developed for northern long-eared bats, and based on the similarity in habitat requirements of, and threats to, the two Covered Species, the Applicant referred to the above recovery action priorities in identifying mitigation projects for both Covered Species.

The Applicant has, in consultation with the USFWS, developed mitigation criteria that serve as standards for an acceptable mitigation project or projects to be undertaken, including the use of certified conservation banks. These criteria are:

1) Must be a hibernaculum; habitat (roosting, foraging, and/or travel corridor) within the swarming radius of a hibernaculum; or suitable maternity colony habitat

(roosting, foraging and/or travel corridor) with documented use by Indiana bats and/or northern long-eared bats;

2) Must be supported by a threats analysis of the hibernaculum, swarming habitat, or summer maternity habitat that indicates that human activity or other disturbances (e.g., likely land-use change) presents a threat of partial or total loss of the habitat or disturbance to Covered Species using the habitat;
3) If roosting, foraging, and/or travel corridor habitat is to be used for mitigation, it must meet all of the requirements for each habitat function defined in the USFWS REA models specific to each Covered Species;
4) Must ensure that a landowner (public or private) of the hibernaculum, swarming habitat, or summer maternity habitat is willing to have the project implemented, and a third-party conservation entity that can ensure protection of the habitat in perpetuity is enlisted;
5) Must grant the USFWS and/or a state wildlife agency future access to the mitigation site to monitor Covered Species' populations and/or use of the habitat; and
6) If the hibernaculum, swarming habitat, or summer maternity habitat is vulnerable to anthropogenic harm through multiple access points or in multiple ways, the Applicant must provide funding to fully protect the habitat (e.g., gate all entrances of a cave, address all anticipated possible land use changes [including mineral extraction], etc.).

5.3.1 Mitigation Project Implementation

The Applicant will implement mitigation to offset the entire predicted impact of take for the term of the ITP as soon as possible, as recommended in the HCP Handbook (pg 9-27), but no later than in the first 2 years after receiving the requested ITP. The Applicant will implement the first mitigation project within 1 year of receiving the requested ITP. It is possible that the Applicant may need an extension on these mitigation timelines in the event of unforeseen logistical constraints that prevent timely implementation of the mitigation projects; unwillingness of landowner(s) to sign the necessary conservation easement(s) or signature of conservation easement(s) too late in the season to implement cave gating when bats are not present are examples of constraints that would qualify as requiring an extension of the mitigation timeline. In this event, the Applicant would request a written extension from the USFWS. .

The HCP Handbook (pg 9-27) provides for situations in which it is not possible to implement a mitigation project prior to the beginning of take impacts, recommending that the type and level of impacts that would occur during the time lag are determined, and the HCP ensures that the proposed mitigation, once implemented, would also offset those impacts that occur during the lag. Although the Applicant's request for a period of up to one year after issuance of the ITP to complete implementation of the first mitigation project (due to potential logistic constraints) may create a minor lag between the beginning of impacts to the Covered Species and the beginning of the mitigation program, the impact of take that is anticipated to occur during this time (18.55

Indiana bats and 3.26 northern long-eared bats; 4% of the total impact of take) will be more than offset by the first mitigation project by no later than the end of Year 1 of the ITP. The first mitigation project, which will be implemented as soon as possible after ITP issuance, is estimated to offset 4.6 years of Indiana bat take impacts (85 Indiana bats; see Appendix A), which will immediately set the mitigation ahead of the impact of the taking even if the entire one-year lag has occurred. This mitigation project will also benefit any northern long-eared bats that may occur in the cave, although their population cannot currently be quantified in the hibernaculum. Additionally, the Applicant has contracted with a mitigation entity for the implementation, by Year 2, of mitigation project(s) sufficient to fully offset the rest of the predicted impact of take. Therefore, the entire predicted impact of the take under the HCP will be offset by Year 2 of the ITP, which will set the mitigation far ahead of the impact of the take.

Furthermore, the HCP Handbook provides for situations in which impacts and mitigation occur simultaneously during the ITP term (pg 9-27). This will be the scenario for implementation of this HCP, which has structured mitigation to be implemented with two projects (with the first mitigation project implemented within one year of ITP issuance and the other mitigation project[s] implemented no later than Year 2 of the ITP) and to be shored up with the estimated impact of the take in a series of increments during the ITP term, such that mitigation stays well ahead of the impact of take and provides a conservation “cushion”, as recommended by the HCP Handbook (pg 9-28).

For the remainder of the ITP term, mitigation will then be evaluated in a series of 6-year increments. During the first 6-year increment, as previously stated, the Applicant will implement mitigation to offset the entire predicted impact of take for the lifetime of the permit; the latter increments will be used to compare the actual impact of take against the mitigated amount and to calculate any extra mitigation credit accrued. Because the minimization measures are expected to reduce take of the Covered Species more than the predicted levels, and because take predictions were based on the 60th credible interval output from the EoA model, the Applicant anticipates that the mitigation increment approach will result in a mitigation buffer, with mitigation amounts exceeding the level necessary to offset the impact of the actual estimated take, thereby keeping mitigation ahead of the take and providing a conservation benefit to the species. The 6-yearincrement approach works as follows.

During the initial 6-year increment, predicted take will be mitigated according to REA models. In other words, mitigation project(s) will be selected that offset the impact of take equal to 501 Indiana bats and 88 northern long-eared bats (based on the impact estimated from 100 turbines that take 18.55 Indiana bats and 3.26 northern long-eared bats annually as calculated by applying the REA models; see Tables 4.1 and 4.4). The credit value of a mitigation project will be determined using the REA models and a stacking discount of 10% per species, applied per USFWS guidance, will be used to adjust the credit for any project providing mitigation credit for both Covered Species.

The mitigation requirement for the next 6-year increment will be based on the estimated impact of cumulative take (or M_{50}) generated by the EoA model and the REA model for data collected during the first five years. For example, it is currently predicted that the impact of take during the first 6-year increment will be 111 Indiana bats and 20 northern long-eared bats (based on the impact estimated from 100 turbines that take 18.55 Indiana bats and 3.26 northern long-eared bats annually during the first six ITP years as calculated by applying the REA models; see Tables 4.1 and 4.4). This predicted impact of take will be compared to the actual impact of take calculated from the compliance monitoring take estimates (again by applying the REA models). Any surplus mitigation credit that may have been accrued during the first 6-year increment, as a result of the estimated impact of take being lower than the predicted impact of take, will be subtracted from the mitigation requirement for the next 6-year increment. That process will be repeated for every subsequent increment through the end of the ITP term, which will ensure that mitigation stays ahead of take and provides a credit buffer for the final 6-year increment, for which the estimated impact of take will not be known until afterwards.

If, based on the first 6-year increment analysis, the mitigation project(s) selected will provide more mitigation credit than necessary to offset the impact of take under this HCP, the Applicant may work with the USFWS to establish a conservation fund with these projects. The conservation fund would allow the Applicant to store surplus credit from the mitigation project(s) secured for this HCP and enable that surplus credit to be withdrawn to offset the impact of take under other qualifying HCPs in development by the Applicant in Region 3. The conservation fund and the ledger for tracking credit assigned to offset impact of take are described in Appendix D. The conservation fund ledger is a living document that will be updated every sixth year of the requested ITP; the updated ledger will accompany that year’s monitoring report to the USFWS.

The Applicant would update the amount of credit logged in the fund just prior to the beginning of each 6-year increment. At the end of each 6-year increment, the amount of mitigation credit predicted to offset the impact of take for that period would be compared to the actual impact of take estimated from the monitoring data collected during the same 6-year period and any surplus mitigation credit would be deposited back into the fund. Conversely, if the amount of mitigation credit predicted for the period was less than the actual impact of take, the mitigation credit in the fund would be adjusted and the predictions for the next 6-year increment would be increased according to the take estimates calculated in the prior increment[23]. This process will be repeated for the duration of the ITP.

The Applicant will aim to have a Service-approved mitigation project or projects designed and ready to be implemented as soon as possible but no later than 3 years after receiving the requested ITP, so that mitigation outpaces take. Although the specific mitigation property(ies) has not yet been identified, the Applicant has already contracted with a mitigation entity to provide mitigation credits more than sufficient to offset the impact of predicted take of this HCP.

[23] It is very likely that this event would be accompanied by an adaptive management action, due to the higher-than-expected actual take. The estimated take, and consequently the amount of mitigation credit necessary, for the next 6-year period after the adaptive management action would be calculated as described in the adaptive management plan (Section 5.4.3).

5.3.2 Selected Mitigation Project

The Applicant has worked with the USFWS to identify a mitigation project to offset the initial impact of the taking for Indiana bats (and possibly northern long-eared bats, if they return to the hibernaculum): gating of Wind Cave in Wayne County, Kentucky. The Applicant intends to implement gating of Wind Cave as the first mitigation project to offset the impact of take for this HCP. For a detailed description of the project and the amount of mitigation credit produced by the project, refer to Appendix A.

Wind Cave is a P2 Indiana bat hibernaculum. In 2015, the cave was home to 2,878 Indiana bats (down from 3,537 observed in 2013). As many as 60 northern long-eared bats were also observed in the cave in 2013; however, subsequent acoustic monitoring conducted in 2015 revealed that northern long-eared bats are no longer present in the cave in any appreciable numbers (Armstrong, USFWS, pers. comm.). Other bat species known to use the cave include the little brown bat, tri-colored bat, eastern small-footed bat (*M. leibii*), big brown bat, and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*).

Wind Cave is considered by the USFWS Kentucky Field Office (KFO) and the Kentucky Department of Fish and Wildlife Resources (KDFWR) to be the highest priority cave left to be gated in Kentucky. The cave location is well-known to the public, the entrance is located near a road, and the landowner has noted use of the cave by trespassers. It is highly likely that this use creates disturbance for hibernating Indiana bats since greater than 75% of the hibernating population of Indiana bats in the cave is clustered in low ceiling areas that are vulnerable to disturbance or predation. Due to the fact that Indiana bat populations are currently being decimated by WNS, protection of hibernacula from additional sources of stress is of the utmost importance.

The mitigation project will entail gating the cave to minimize the potential for Indiana and northern long-eared bats (if northern long-eared bats return to the cave) to be negatively affected by potential vandalism in the future, providing an important conservation benefit for both species. The gating is being implemented in phases between 2015 and 2019. The gate will be designed and installed in a manner intended to avoid impacts to the Covered Species and other bats in the cave, and monitoring will be conducted to ensure the project's effectiveness.

5.3.3 Additional Mitigation Project Selection

According to the HCP Handbook, mitigation must be based on the biological needs of covered species and should be designed to offset the impacts of the take from the covered activities to the maximum extent practicable. The REA models and the USFWS Guidelines for Non-REA Staging/Swarming Mitigation Option developed by the USFWS cover both Covered Species. The Service has directed the Applicant to use those frameworks to select mitigation projects and to calculate the mitigation credits that accrue. The frameworks for each Covered Species allow the calculation of credits (i.e., gains in reproduction resulting from habitat protection and restoration) that are expected to offset debits (i.e., take of females that reduces reproduction, described in Section 4.0). The rate of accumulation of credits is different for each Covered Species because of differences in demographic parameters.

Four types of mitigation projects qualify for credit in the REA model or the USFWS Guidelines for Non-REA Staging/Swarming Mitigation Option frameworks. Therefore, mitigation project(s) implemented in addition to the Wind Cave gating project will entail one or more of the following options:

1.) Protection of an occupied hibernaculum – under this option, a cave or mine occupied by Indiana bats and/or northern long-eared bats within at least the past two years would be protected through the installation of bat-friendly gates at all entrances. Stabilization of the hibernaculum structure (e.g., for unstable mine shafts), and/or efforts to regulate a hibernaculum's temperature may also be part of the mitigation work. If not already located on land protected for conservation (e.g., restricted with a conservation easement or owned by state or federal wildlife agency or conservation non-profit), the land on which the hibernaculum is located (e.g., out to a 0.40-km [0.25-mi] buffer) would be protected, in perpetuity, through a conservation easement. The gate(s) would periodically be checked to ensure it remains clear of debris, has not been vandalized, and is functional. Hibernacula with a documented history of human disturbance, with large areas of hibernating bats susceptible to disturbance or non-disturbance threats (such as unstable mine shafts) and/or those demonstrating WNS resilience will be prioritized for selection as mitigation projects. In general, hibernaculum protection projects are designed to protect and improve the overwinter survival of hibernating bats by preserving and/or enhancing hibernation habitat.
2.) Protection of occupied summer maternity colony habitat – under this option, suitable summer habitat, which includes roosting and foraging habitat, as well as travel corridor habitat (i.e. habitat that connects forest patches) within the home range (defined per USFWS guidance) of an Indiana bat and/or northern long-eared bat maternity colony documented within at least the past two years would be protected, in perpetuity, through a conservation easement. Enhancement of the habitat (e.g., tree girdling, installation of artificial roosting substrate, management of invasive vegetation) may also be part of the mitigation work. The habitat would be periodically evaluated to ensure it remains suitable maternity colony habitat for Indiana bats and/or northern long-eared bats and has not been vandalized or compromised by a natural disaster (e.g., flooding). High-quality summer habitat at risk of development or vandalism, or habitat connected to other areas of suitable and/or protected habitat will be prioritized for selection as mitigation projects. In general, summer habitat protection projects are designed to protect and improve summer survival and reproduction rates of maternity colonies by preserving suitable habitat.
3.) Restoration of occupied summer maternity colony habitat – under this option, habitat suitable for restoration to roosting and foraging habitat, as well as travel corridor habitat (i.e. habitat that connects forest patches) within the home range (defined per USFWS guidance) of an Indiana bat and/or northern long-eared bat maternity colony documented within at least the past two years would be identified and actions to restore

the habitat would be implemented. If not already protected for conservation (e.g., conservation easement, owned by state or federal wildlife agency, or conservation non-profit), the habitat would be protected, in perpetuity, through a conservation easement. The mitigation work may include tree planting, tree girdling, installation of artificial roosting substrate, pond construction, wetland restoration, and/or management of invasive vegetation. The habitat would be periodically evaluated to determine progress toward the establishment of suitable maternity colony habitat for Indiana bats and/or northern long-eared bats. Once suitable habitat conditions have been achieved, the habitat would be periodically evaluated to ensure it remains suitable maternity colony habitat for Indiana bats and/or northern long-eared bats and has not been vandalized or compromised by a natural disaster (e.g., flooding). Marginal or low-quality habitat that is suitable (i.e., has the right conditions) for restoration that is located near or connected to other areas of suitable and/or protected habitat will be prioritized for selection as mitigation projects. In general, summer habitat restoration projects are designed to improve summer survival and reproduction rates of maternity colonies by increasing the amount of suitable habitat available.

4.) Protection of occupied swarming habitat – under this option, suitable roosting and foraging habitat within the swarming distance (defined per USFWS guidance) of a hibernaculum occupied by Indiana bats and/or northern long-eared bats within at least the past two years would be protected, in perpetuity, through a conservation easement. Swarming habitat may overlap suitable summer maternity colony habitat – in which case credit would be given through both the REA model and the USFWS Guidelines for Non-REA Staging/Swarming Mitigation Option. Enhancement of the habitat (e.g., tree girdling, installation of artificial roosting substrate, management of invasive vegetation) may also be part of the mitigation work. The habitat would be periodically evaluated to ensure it remains suitable roosting and foraging habitat for Indiana bats and/or northern long-eared bats and has not been vandalized or compromised by a natural disaster (e.g., flooding). High-quality roosting and foraging habitat at risk of development or vandalism, habitat connected to other areas of suitable and/or protected habitat, and habitat within the swarming distance of high-priority hibernacula or hibernacula complexes will be prioritized for selection as mitigation projects. In general, swarming habitat protection projects are designed to protect and improve overwinter survival by preserving suitable habitat for pre-hibernation foraging.

Any mitigation project(s) implemented in addition to the Wind Cave gating project will be located in the state of Indiana. The Applicant will identify and prioritize potential mitigation project(s) in coordination with the USFWS and the Applicant will require USFWS approval of any proposed mitigation project(s) prior to implementation.

5.4 Monitoring and Adaptive Management

A monitoring program will be implemented as part of this HCP to verify ITP compliance through evaluation of the level of take of the Covered Species, to provide progress reports on the fulfillment of mitigation requirements, and to enable evaluation of the effectiveness of the minimization and mitigation actions in meeting the biological goals and objectives (Section 5.1). The monitoring program consists of compliance monitoring to evaluate the level of take of the

Covered Species at the Project, and mitigation effectiveness monitoring to ensure that the mitigation projects are implemented and functioning as planned. Monitoring results will be reported to the USFWS after each year of monitoring.

5.4.1 Compliance Monitoring

The primary objective of compliance monitoring is to estimate take of Covered Species that has occurred as a result of collision with operating turbines. Results of compliance monitoring will provide the basis for adaptive management decisions. Carcasses of the Covered Species may never be found during the ITP term because fatalities are expected to occur as rare events; however, this monitoring plan will allow tracking of the cumulative take of Covered Species throughout the ITP term through the use of statistical estimators. If new information becomes available to suggest improved, cost effective, and logistically feasible methods for estimating bat mortality, the Applicant will consult with the USFWS regarding changes to the protocol and implementation of applicable new methods. Please note that although this monitoring plan has been designed specifically for this objective, all bat and bird carcasses found during monitoring will be recorded and a summary of the bat and bird carcasses found will be included in the monitoring reports; fatality rates will not be estimated for non-listed bats or birds as part of the monitoring plan.

The Applicant has designed this monitoring approach to use monitoring resources in intervals to collect robust, useful data that provide confidence in the take estimates throughout the ITP term. Populations of the Covered Species are currently reduced due to WNS and are likely to experience lower levels of take due to fewer bats on the landscape; this may change as populations stabilize and begin to recover from WNS. The resulting changes in take are likely to be incremental and difficult to detect without robust monitoring. Changes are also likely to be gradual, given that *Myotis* bat populations grow slowly due to their life histories and are likely to require several generations, possibly much longer, to return to pre-WNS levels. Substantial variation in take of the Covered Species is not expected to occur at the annual scale; eight years of pre- and post-ITP monitoring at the Fowler Ridge Wind Farm have shown a consistent overall bat mortality rate over time and have not shown large swings in Indiana bat or northern long- eared bat mortality (Good et al. 2011, 2012, 2013a, 2013b, 2014b, 2016b, 2017, Johnson et al. 2010a, 2010b). If Covered Species populations do not stabilize but continue to decline rapidly due to WNS, this HCP includes a changed circumstance to respond to this event (see Section 8.2.2).

The monitoring framework is based on the purpose of monitoring with a probability of detection sufficient to produce an estimate of zero take if no carcasses of the Covered Species are detected. This provides a fundamental level of confidence in the monitoring data. Data collected with the proposed probability of detection provide a more accurate assessment of the actual take occurring at a site compared to annual low-level monitoring, and are optimally useful for evaluating compliance with an ITP take limit. Therefore, the Applicant’s proposed monitoring framework achieves a level of monitoring sufficient to provide monitoring data to support an accurate evaluation of compliance with the requested ITP on an interval appropriate for detecting the anticipated potential trends in Covered Species take over the ITP term.

5.4.1.1 Monitoring Protocol and Schedule

The Applicant proposes to conduct compliance monitoring according to the framework provided in Table 5.1. Monitoring will be conducted in intervals throughout the 27-year ITP term according to a standard protocol for post-construction monitoring; an example protocol is provided in Table 5.2. This protocol will be updated as necessary to ensure the target probability of detection (or *g* value) of 0.25 (or 25% detection) is attained in each monitoring year. The probability of detection is sensitive to area searched, searcher efficiency, and carcass persistence.

Because numerous monitoring protocol designs can achieve a target *g* value of 0.25, and because the monitoring protocol designs that can achieve this *g* value will depend on the prior year of bias trial data and the operational strategy (i.e., cut-in speed) of the Project at the time, the monitoring protocol for each monitoring year will be designed at the conclusion of the previous year of monitoring. The monitoring protocol for each year will be submitted with the previous year's monitoring report (summarizing the prior year of monitoring) for USFWS approval. This approach will enable the Applicant to modify the monitoring protocol as necessary to achieve the target *g* value, while also selecting the most cost-effective or logistically feasible protocol.

While the protocol in Table 5.2 serves as an example of the monitoring that may be implemented it is not necessarily the actual protocol that will be implemented. The reason Year 1 monitoring is not fixed at this time is that there may be results of monitoring between the writing of this document and when the requested ITP is issued that could inform a different monitoring protocol that could achieve a *g* value of 0.25.

If new information becomes available to suggest improved methods for estimating bat mortality, the Applicant may consult with the USFWS regarding cost effective and logistically feasible changes to the protocol and implementation of applicable new methods, per the New Technology and Information changed circumstance (Section 8.2.4).

In addition to the standardized monitoring, the Applicant will implement O&M monitoring for the life of the Project. O&M monitoring will be conducted using the Applicant's Wildlife Incident Reporting System (WIRS). The purpose of the WIRS procedure is to standardize and describe the actions taken by site personnel in response to wildlife incidents found at the Project. The Applicant has provided a guidance document to site personnel which is intended to provide directions for site personnel who may encounter a wildlife incident, and to fulfill the obligations of the Applicant in reporting wildlife incidents. The Applicant will maintain a record all dead birds and bats found incidentally in the Project over the entire life of the Project as part of the O&M monitoring efforts.

Table 5.1 Compliance Monitoring framework for the Headwaters Wind Farm.

Year of ITP	Monitoring	Probability of Detection (g)	Purpose
1 2 3	Standardized	0.25	Establish baseline take estimates under ITP, with *g*≈0.25 to provide an estimate of 0 if 0 carcasses found
4 5 6 7	Operations & maintenance (O&M)	0.001*	Document and report Covered Species Carcasses found incidentally
8	Carcass removal bias trials	0.001	Determine study design to achieve g=0.25 in year 9 assuming searcher efficiency is similar to years 1-3
9	Standardized	0.25	Update take estimates under ITP
10 11 12 13	Operations & maintenance (O&M)	0.001	Document and report Covered Species Carcasses found incidentally
14	Carcass removal bias trials	0.001	Determine study design to achieve g=0.25 in year 15 assuming searcher efficiency is similar to years 1-3 and 9
15	Standardized	0.25	Update take estimates under ITP
16 17 18 19	Operations & maintenance (O&M)	0.001	Document and report Covered Species Carcasses found incidentally
20	Carcass removal bias trials	0.001	Determine study design to achieve g=0.25 in year 21 assuming searcher efficiency is similar to years 1-3, 9, and 15
21	Standardized	0.25	Update take estimates under ITP
22 23 24 25	Operations & maintenance (O&M)	0.001	Document and report Covered Species Carcasses found incidentally
26	Carcass removal bias trials	0.001	Determine study design to achieve g=0.25 in year 27 assuming searcher efficiency is similar to years 1-3, 9, 15, and 21
27	Standardized	0.25	Update take estimates under ITP

* This value represents 0 in the EoA model because the model cannot accept an input of 0.

Actual monitoring protocols will be designed based on data from the previous year of monitoring using the EoA model, as described in Appendix B.

Table 5.2 Example protocol for Compliance Monitoring that would provide a probability of detection of 0.25 at the Headwaters Wind Farm.

Monitoring Season	Number of Turbines Searched	Plot Radius	Plot Type	Search Interval
Spring (April 1 - May 15)	41	70 m (230 ft)	cleared	weekly
Summer (May 16 - July 31)	10[1]	100 m (328 ft)	road and pad	weekly
Fall (August 1 - October 15)	41	70 m (230 ft)	cleared	twice per week
Fall (August 1 - October 15)	59	100 m (328 ft)	road and pad	weekly

[1] All turbines with summer risk; summer monitoring may be conducted by trained O&M staff.

5.4.1.2 Monitoring Methods

Cleared plots at the search turbines will be planted with grass and mowed regularly to maintain grass height at 10 cm (4 inches) or less to increase searcher efficiency. Cleared plots and roads and pads will be searched by walking transects spaced 5 m apart; searchers will walk transects at approximately 45-60 m (148-197 ft) per minute and scan the ground up to 2.5 m (8.2 ft) away from the transect. Road and pad searches will be conducted on only the gravel road and pad portions around the turbines which will be searched out to a specified search radius.

Data Collection and Processing

All bird and bat carcasses located within the search areas (i.e., cleared plots and roads and pads) will be recorded. Injured birds or bats will be recorded and treated as a fatality for the purposes of the analyses. The following information will be recorded for each carcass: a unique identification code, sex and age when possible, date and time collected, observer, carcass condition (i.e., intact, scavenged, dismembered, injured or feather spot), injuries, scavenging, estimated time of death, Universal Transverse Mercator (UTM) location, distance and bearing from the turbine, habitat and any relevant comments. All carcasses will be photographed as found and plotted on a map of the search area. Bat carcasses will be collected and species identification will be verified by bat biologists permitted by the USFWS and IDNR to survey for Indiana and northern long-eared bats. Skin and tissue samples from bat carcasses too decomposed to be identified by permitted bat biologists will be sent to a qualified lab for identification via DNA sampling. Bird carcasses will be identified, photographed and left in the field. The identification of bird carcasses will be verified by qualified field biologists with significant field experience in bird identification. Bird carcasses will be spray-painted to identify them as previously recorded. Carcasses found outside of the standardized search area or within the search area on a day when a scheduled search is not taking place will be recorded following the above protocol, and labeled as incidental finds.

Bias Correction

The objective of the searcher efficiency trials is to estimate the proportion of available carcasses found by searchers. Searcher efficiency trials will be conducted in the same areas as carcass searches and will be estimated by search area type (cleared plot or road and pad) and season. The most appropriate searcher efficiency model among models including search area type, season, and their interaction will be selected based on Akaike's Information Criterion, adjusted for sample size. The selected searcher efficiency model will be used to adjust the total number of bat carcasses found for those missed by searchers, thereby correcting for detection bias.

Searcher efficiency trials will be conducted during each month of the monitoring period. The person placing the carcasses will not inform the personnel conducting the searches when the trial is being conducted or where trial carcasses are placed. Approximately 100 bat carcasses or bat surrogate carcasses will be placed in roughly even numbers across search area types (i.e., approximately four to five carcasses per search area type [cleared plots/roads and pads], per month). Carcasses of non-listed bat species found on-site, and carcasses of non-listed bat species that are available from labs or other sources, will be used in the trials. If an insufficient number of bat carcasses is available, brown or black mice (*Mus musculus*) carcasses may be used as surrogate bat carcasses.

All searcher efficiency trial carcasses will be placed at random locations within the search area prior to that day's scheduled carcass survey. Each trial carcass will be discreetly marked so that it can be identified as a study carcass after it is found. The number and location of the searcher efficiency carcasses found will be recorded. The number of carcasses available for detection during each trial (i.e., that were not removed by scavengers before searchers could search for them) will be determined immediately after the trial by the person responsible for placing the carcasses.

The factor by which searcher efficiency changes as undetected carcasses age (k) is difficult to estimate in the field because it requires a large number of carcasses to be tracked through multiple searches. However, a recent analysis (Huso et al. 2017) indicated that 0.67 is a reasonable value to use for k for bats. Unless a better estimate becomes available, k will be assumed to be 0.67.

The objective of carcass persistence trials is to estimate the average probability a carcass is available to be found after an interval of time. The probability is determined by the length of time a carcass remains in the search area before being removed by scavengers or by other means. Possible means of carcass removal include removal by scavengers, insects, or agricultural practices, such as being plowed into a field. Estimates of carcass persistence will be used to adjust fatality estimates for removal bias.

Carcasses will be placed within search area boundaries. Carcass persistence trials will be conducted throughout the monitoring period to incorporate the effects of varying weather, climatic conditions, and scavenger densities. Species used for carcass persistence trials will be the same as used for searcher efficiency trials. Approximately 50 bat carcasses or bat surrogate carcasses will be placed during the carcass persistence trials. Persistence trial carcasses will be marked discreetly (e.g., with zip ties) for recognition by searchers and other personnel.
Field personnel will monitor carcass persistence trials for 30 days. Trial carcasses will be checked every day for the first four days, and then on day seven, day 10, day 14, day 20, and day 30 after placement. At the end of the 30-day period, any remaining evidence of the carcass will be removed.

Take Estimation

The EoA model will be used to assess take rates and cumulative take of both Covered Species each year. The rolling average 6-year take rate (λ in the EoA model) will be updated each year to assess whether the short-term adaptive management trigger (Section 5.4.3) has been met and adaptive management responses are needed. The cumulative (ITP term to date) take estimate will be updated each year to assess whether the projected cumulative take amount (M^*) has met the permitted take amount.

5.4.2 Mitigation Effectiveness Monitoring

A detailed habitat management plan will be developed for each proposed mitigation project. The habitat management plan will include but not be limited to background information on the habitat, a threats analysis, the action and implementation strategy for the project, a description of the project monitoring, an adaptive management strategy, and the reporting process. The plan will describe: the entity responsible for periodic evaluation of the mitigation project, the frequency of the periodic evaluation, and corrective actions to be taken if the periodic evaluation indicates that the habitat quality of the project has been compromised by vandalism or natural disaster.

The summer/swarming habitat management plan will be submitted to the USFWS for approval (see Section 5.3.1). Because initial survey efforts are already underway for the winter mitigation project, the winter habitat management plan has been developed and was approved by the USFWS in October 2016 (Appendix E).

For summer/swarming habitat preservation projects, the purpose of the monitoring will be to ensure that the habitat conditions are maintained and that protections are adequate. Details of the summer mitigation project monitoring will be included in the management plan to be approved by the USFWS. The monitoring will include an assessment of the functionality of the habitat protection measures, the need for any maintenance measures, and an assessment of threat abatement due to the project. Monitoring, likely through site visits, will be conducted on a biannual basis to ensure the habitat remains suitable and protected from destruction or degradation.

For hibernacula protection projects, the purpose of the monitoring will be to ensure that gates continue to provide adequate protection. As described in the winter habitat management plan, monitoring will entail thermal infrared camera monitoring of the cave entrance during the first year following gate construction, climate logger monitoring during the first two years following gate construction, and monitoring of human activity through the use of speloggers or similar equipment during the first three years following gate construction. These monitoring efforts are intended to confirm that the newly installed gate is not affecting egress/ingress or swarming behavior, is not affecting climate conditions in areas of the cave where Indiana bats hibernate, and that the gate was installed correctly and that it will function effectively through its operational life. In addition, Wind Cave will be regularly surveyed by the KDFWR to track the number and species of hibernating bats on at least a biennial basis for the foreseeable future. However, if the KDFWR or the USFWS cannot continue their biennial monitoring efforts for any reason, the Applicant will provide funding and/or personnel to continue monitoring efforts for the remainder of the ITP term. Any applicant sponsored monitoring will be coordinated and approved by KDFWR and USFWS, and will follow the established protocol and schedule for Wind Cave. In such a case, at least one person with prior knowledge of the cave would be present during the first year of monitoring by Applicant-sponsored personnel.

5.4.3 Adaptive Management

Adaptive management will be used to ensure the take of Covered Species at the Project does not exceed the permitted level of take due to uncertainty in predicting take. The EoA model will provide an estimate of the take rate (λ) and the cumulative take (M*) based on data collected during the monitoring. Dalthorp and Huso (2015) provide a framework for two types of adaptive management tests in EoA: 1) a short-term test of whether the average take rate is on pace to exceed the expected average rate, and 2) a long-term test of whether the total cumulative take has met the permitted level of take. The short-term test is designed to trigger an adaptive management response in time to prevent the cumulative take estimate from actuating a response to the long-term test. The long-term test is designed to ensure compliance with the permitted take limit and will trigger an avoidance response if the take limit is met.

Short-term triggers are built into the EoA model to assess the average rate of take within a defined rolling window; the window has been set to a six-year rolling window for this HCP to ensure that at least one year of intensive monitoring data are available to inform the estimate of λ in any given window. However, if data collected during the first five years of the requested ITP provide early indication of an ITP compliance issue, the Applicant may respond sooner than the end of the first six-year window. If, within any 6-year rolling window, the estimated take rate exceeds the expected take rate with 95% confidence, the short-term trigger will be met. The confidence for the trigger has been reduced from the standard EoA value of 99% to make it more sensitive. This trigger will indicate that the minimization plan may need to be adjusted to ensure the cumulative take estimate (the median of M*) is within the permitted limit over the ITP term. The short-term trigger is set at a high confidence level to prevent premature responses. The short-term trigger will be evaluated in the monitoring report (Section 5.4.4), and any required response will be implemented before the start of the next monitoring cycle (i.e. April). The USFWS will be notified prior to the implementation of any proposed adaptive management response.

The Applicant may adjust the turbine cut-in speed in response to a short-term trigger, but the Applicant may alternatively choose to implement a different response (e.g., adjustments to the temperature threshold, deterrents, increased monitoring, adjustments to the turbine operation algorithms, etc.) to a short-term trigger, as long as the take limit has not been met. Because the short-term trigger is designed to provide an early indication that the cumulative take estimate may not be sustainable (i.e., within the permitted level) over the ITP term but does not indicate that the take limit has been met, the Applicant reserves some flexibility in the short-term trigger response.

If an alternative response, such as changing the minimization temperature threshold, is determined based on the monitoring data and in coordination with USFWS, to have a similar or greater effect on all bat mortality as could be expected from the standard response (i.e., raising cut-in speed by 0.5 m/s), the Applicant may implement this response instead.

For example, if monitoring data reveal that 25% or more of documented fatalities occur on nights when average temperature is below 10°C, as determined through analysis of mortality data at the conclusion of the monitoring period, this would indicate that at least 25% of the Covered Species take may not be minimized during the minimization period (Section 5.2.2). The adaptive management response would be to resume turbine operational adjustments for the entire night, irrespective of temperature[24], which would be expected to result in an additional 12.5% or more reduction in bat fatality (0.5 minimization effect [per Section 5.2.2] * 25%).

The Applicant may implement a reversion trigger, as approved by USFWS, if the monitoring data collected to date indicate the take rate is below the lesser of the expected annual average take rate or the average annual take rate as measured during the first three years of the ITP; in this case, the Applicant may reduce the turbines' cut-in speed in 0.5 m/s increments. The Applicant will reevaluate the trigger after each subsequent monitoring year to assess whether reduced minimization measures should be implemented. The reversion trigger may also fire after a short-term adaptive management response has been implemented, if monitoring data collected in the future indicate the take rate no longer exceeds the predicted take rate; in this case, the adaptive management response would cease to be implemented. For example, the Applicant retains the option to re-implement the temperature threshold if subsequent monitoring data show that more than 75% of documented fatalities occurred on nights when average temperature was above 10°C. This would indicate that the original assumptions about the effectiveness of the temperature threshold are supported and the take rate of the Covered Species should be minimized as predicted.

If a short-term trigger or a reversion trigger is fired in a given year, or if an Indiana bat carcass and/or a northern long-eared bat carcass is found incidentally during O&M monitoring, the Applicant will reschedule the next year of monitoring (at a g of 0.25) to occur in the next year. The purpose of this monitoring will be to update the take estimate and check for changes in the take rate. Because there will not be an opportunity to conduct bias trials the year prior to the rescheduled year of monitoring, the monitoring protocol will be designed using best available data from the most recent bias trials conducted at the Project. The monitoring schedule will resume such that the next bias trials are conducted five years after the previous monitoring and standardized searches are conducted every sixth year after the rescheduled monitoring. If the short-term trigger is met by the results of this monitoring, the Applicant will again implement a response as described above.

In addition to the short-term triggers, the EoA model has a long-term trigger, which indicates that the permitted level of take has been met (based on the cumulative estimated take using the median of M). The long-term trigger will be evaluated in the monitoring report (Section 5.4.4), and any required response will be implemented before the start of the next monitoring cycle (i.e. April). In response to the long-term trigger, the Applicant will implement an operational plan, approved by the USFWS, under which take of the Covered Species is not likely to occur (i.e., an avoidance strategy such as the current USFWS recommendations to feather turbines at wind

[24] Should the Applicant be required to disable the temperature-controlled cut-in wind speed adjustment parameter, the turbine control software would be reconfigured remotely and rolled out to each individual turbine.

speeds below 6.9 m/s). The Applicant will then consult with the USFWS to determine whether the Project will operate under the avoidance strategy or pursue a permit amendment.

5.4.4 Reporting

The Applicant will prepare data sheets and report templates for monitoring that will be reviewed and approved by the USFWS prior to initiation of the first year of compliance monitoring under the requested ITP. During active monitoring, raw data forms will be stored on site and at the offices of the independent monitoring contractor. Individual carcasses collected will be stored in a freezer located at the Project O&M facility and hair and tissue samples from each carcass will be submitted to the INFO after each monitoring year. Raw data forms will be made available to the USFWS upon request. For each bat carcass found, the following information will be maintained in a database that will be provided to the USFWS annually or more frequently upon request: a unique identification code, sex and age when possible, date and time collected, observer, carcass condition (i.e. intact, scavenged, dismembered, injured or feather spot), injuries, scavenging, estimated time of death, Universal Transverse Mercator (UTM) location, distance and bearing from the turbine, habitat and any relevant comments, and, if available, temperature and wind speed for the night preceding a *Myotis* fatality (of any *Myotis* species, not just Covered Species).

Although permitted, in the event that a Covered Species fatality is documented during the compliance monitoring, the USFWS and the IDNR will be notified by phone within 24 hours of positive species identification. The USFWS and the IDNR will also be notified by phone within 24 hours of positive identification of a carcass of an eagle, a species listed as endangered or threatened under the ESA, or a state-listed threatened or endangered species. Additionally, any carcasses of listed species or eagles discovered will be turned over to the USFWS within two business days of positive identification.

The Applicant will submit a compliance monitoring report to the USFWS no later than January 31 following each monitoring year (approximately four to five months following completion of the monitoring studies). Reports will be presented in standard scientific format (Introduction, Methods, Results, Discussion, and References). Each report will include results from the compliance monitoring, data demonstrating turbine operations, and any adaptive management actions taken. The report will also include the protocol for the next year of monitoring, designed based on the monitoring data in the report. A final compliance monitoring report will be prepared following review by the USFWS. This report will also be provided to the IDNR.

The Applicant will complete annual reports following each year of summer mitigation monitoring to be provided to the USFWS. The reports will include a description of the status of the habitat, an assessment of the functionality of the habitat protection measures, and identification of any adaptive management measures necessary. To ensure that any required management actions can be implemented prior to the subsequent maternity period, the summer mitigation monitoring report will be submitted annually by January 31.

The Applicant, in cooperation with the KDFWR, will complete annual reports during the three-year monitoring period of the winter mitigation project, and the reports will be provided to the USFWS KFO and INFO. The reports will evaluate the effectiveness of the new gate in the first year (i.e., evaluation at the time of installation to determine that bats are not impeded by the gate during their passage into and out of the cave) and in subsequent years. The reports will discuss trends in microclimate data and make appropriate management recommendations to mitigate any issues discovered. To ensure that any required management actions can be implemented prior to the subsequent hibernation period, the winter mitigation monitoring report will be submitted annually by June 30.

The Applicant will meet with the USFWS to discuss the monitoring reports following completion of each year's monitoring studies. The purpose of these meetings will be to evaluate the efficacy of monitoring methods, evaluate the results of the compliance and mitigation effectiveness monitoring, and develop recommendations for future monitoring. These annual meetings will also provide opportunity to discuss the effectiveness of the HCP, and to evaluate the status of the mitigation projects. The Applicant will attempt to schedule a meeting with the USFWS in February or March of each year following monitoring studies. This will provide time for the USFWS to review the monitoring reports while allowing for coordination prior to the start of the next bat active period (i.e., April 1 – October 15).

6.0 FUNDING ASSURANCES

ESA § 10(a)(2)(B)(iii) provides that the USFWS shall issue an ITP if, among other things, it finds that "the applicant will ensure that adequate funding for the [HCP] will be provided." Measures requiring funding in an HCP typically include on-site measures during project construction or operation (e.g., monitoring surveys), and off-site measures required for mitigation (e.g., acquisition of mitigation lands). The Applicant will ensure that adequate funding for the HCP will be provided using two financing mechanisms: the Project's annual budget/operating revenue and a bond or guaranty from a Surety.

The Applicant will fund recurring costs associated with implementation of the HCP through operating revenues generated by the Project. These recurring costs (Table 6.1) will be built into the Project's operating budget. The Project has secured a power purchase agreement with a utility that guarantees the Project will be paid for each MW-hour of energy produced, ensuring that adequate revenue will be generated and funds will be available for the required activities. The only situation in which the Project would not earn revenue would be if the Project were to not operate and generate energy. In that situation, the Applicant would lock the Project's turbines and no take of the Covered Species would occur. Therefore, the recurring costs in Table 6.1 would cease to be incurred. Recurring costs include:

- Compliance Monitoring – The Applicant will fund compliance monitoring through the Project's annual operation and maintenance budget. It is important to note that because take is a direct result of turbine operation (i.e., Covered Activity) and is documented in discreet yearly increments, if turbine operation stops, take will also stop and there will be no reason for compliance monitoring. The Applicant will obtain a proposal from an independent consultant for the compliance monitoring for the next year. To provide further assurance that compliance monitoring will occur, the Applicant will submit a letter signed by a responsible corporate official that the Applicant has executed a contract(s) with a qualified party(s) to complete the year's required monitoring activities to the USFWS, by March 1 of each monitoring year of the requested ITP.

- The operational monitoring cost estimates assume that compliance monitoring will be conducted according to the schedule in Table 5.1 for the ITP term. The Year 1 estimates of $182,361 (search costs) and $125,204 (crop clearing costs) were based on current monitoring costs and future years were escalated by 3% per year. The example protocol in Table 5.2 was used for budgeting amounts in Table 6.1; while the example monitoring protocol may not specifically be implemented during the ITP term, it represents approximate levels of monitoring effort, and consequently approximate funding resources, required to meet the target *g* value. At the end of each monitoring year, the report will include a description of the level of monitoring needed to achieve the target *g* value for the next monitoring year.
- For reporting costs, an agency meeting was assumed to occur following each fatality monitoring event in the first quarter of the next year. This would be approximately 90 days after completion of the prior year's monitoring and before the start of the bat active period. The meeting costs are primarily associated with report preparation and logistics for the actual meeting.

- HCP Overhead and Administration – General overhead and administrative costs were estimated to be $4,000 per year starting in 2017 and then escalated by 3% per year for the ITP term. These costs are for travel to USFWS meetings and other expenses, beyond the Applicant's normal (non-HCP) operating budget, related to general administrative tasks, such as on-site coordination of monitoring studies, submitting reports, scheduling meetings, and coordinating O&M monitoring measures as necessary.

Non-recurring costs of plan implementation are also identified in Table 6.1, and include:

- Mitigation Measures –The Applicant has established contracts with conservation entities to implement mitigation projects sufficient to offset the impact of the take. These contracts include: 1) an agreement with a conservation entity to serve as the grantee under the conservation easement for a summer/swarming habitat parcel (yet to be identified) to provide mitigation credits more than sufficient to offset the impact of predicted take of this HCP, and to provide ongoing mitigation, management, and reporting services for the full term of the ITP in accordance with this HCP; and 2) an agreement with Western EcoSystems Technology, Inc. and a pending contract with a USFWS-approved cave gating company to implement the cave gating plan at the Wind Cave hibernaculum. Because the contracts for both mitigation projects have already been executed, no ongoing financial security will be required to guarantee fulfillment of the mitigation obligations under this HCP. Although the summer/swarming habitat project has not yet been identified, the mitigation cost was calculated by the mitigation entity based on the number of credits necessary to offset the impact of the taking. The cost per mitigation credit for the summer/swarming habitat project was based on offsetting the impact of take with 220 acres (89 ha) of habitat providing both summer and swarming functions, as follows:

- Land acquisition: $851,478
- Conservation easement: $120,937
- Mitigation effectiveness monitoring: $428,073
- Reporting requirements: $77,712

The total cost of the summer/swarming habitat project is therefore estimated to be $1,478,200. The mitigation entity is contracted to provide the same number of mitigation credits for this cost regardless of the final combination of summer and swarming habitat acreages protected by the mitigation project(s) selected. Any project(s) selected will meet the criteria identified in Section 5.3.3.

The cost for the Wind Cave gating project was determined based on cost estimates provided by Western EcoSystems Technology, Inc. and a USFWS-approved cave gating company, as follows:

- Pre- and post-construction surveys: $106,250
- Cave gate design and installation: $28,367

The total cost of mitigation credits for the HCP is estimated to be no more than $1,612,817, based on the amount of mitigation that would be necessary to offset the impact of the requested amount of take for this HCP.

- Changed Circumstances - In addition to ensuring funding for the implementation of the required mitigation projects, the Applicant will provide funding assurance for responses to the changed circumstances identified in Section 8.2 that may occur during the ITP term. This assurance would also be used to cover the circumstance in which KDFWR cannot perform the monitoring for the Wind Cave gating project and another party must be engaged to do the monitoring. This assurance will be in the form of a bond or guaranty from a Surety acceptable to the USFWS (e.g., a letter of credit to be maintained by an A3 Moody rated financial institution), secured within three months of issuance of the requested ITP. If a changed circumstance occurs and the bond/guaranty is drawn upon, the Applicant will be required to replenish the bond/guaranty to the full original amount within three months. Any additional bond/guaranty that may be necessary in connection with a modification of the ITP required as a result of one of the changed circumstances would be provided as a condition of issuance of the requested ITP modification. Any additional bond/guaranty that may be necessary as a result of one of the changed circumstances not associated with ITP modification would be provided within three months to maintain compliance with the original ITP. The bond/guaranty will be administered by an independent financial institution and may be drawn upon only in the event that the Applicant fails to fund its obligations under this ITP for any reason. However, in the event the Project permanently ceases operation before the expiration of the permit term and the Service's analysis indicates that the impact of the take that has occurred to that date has been adequately mitigated, the bond/guaranty will not be drawn upon and any unspent funds will be released or returned to the Applicant. If the impacts of the taking have not been adequately mitigated as a result of changed circumstances, the bond/guaranty will be drawn upon to complete the necessary mitigation.

- The Applicant has estimated the foreseeable costs associated with the specified responses to those changed circumstances identified in Section 8.2 at $80,640, and this will be the original amount of the bond/guaranty. This figure is equivalent to 5% of the initial mitigation costs. This percentage was determined appropriate due to the low likelihood of occurrence of the changed circumstances, the implementation of all of the mitigation within two years of permit issuance (including a large amount of surplus credit), and the Applicant's obligation to offset only the remaining impact of take at the time of the changed circumstance (as determined using the REA model; USFWS 2016g and/or USFWS 2016h). If mitigation needs replaced or restored in response to a changed circumstance, it is unlikely that the entire project would need replacement. Additionally, the location of mitigation in the state of Indiana means there is a low likelihood of natural disasters such as wildfire that would cause large-scale destruction of forested habitat, and activities that could destroy the cave gate are rare and unlikely to occur at the selected mitigation hibernaculum. The combination of these factors indicates that additional mitigation to address a changed circumstance is unlikely to be required. The Applicant cannot estimate the potential costs that may be associated with operational adjustments or ITP modifications that might become necessary in response to some of the changed circumstances (for example, a change in migration dates, additional species listings, new technology, etc.) since the nature and extent of the potential adjustments and modifications cannot be predicted. However, these costs would necessarily be reflected and accounted for in the revised operating budgets for the Project (i.e., any reductions in revenue or increases in expenses would be reflected in the Applicant's net income, and if the Project could not operate profitably as a result then operations [i.e., Covered Activity] would be discontinued and no further take would occur).

Table 6.1 Estimated costs for implementing the Headwaters Wind Farm Habitat Conservation Plan.

Budget Item	First Year Cost	Permit Term Total	Cost Basis and Assumptions
Recurring Costs			
General Administration, Management, and Overhead	$4,000	$162,839	Applicant's travel costs for USFWS meetings and other miscellaneous expenses additive to Applicant's normal (non-HCP) operational budget, with 3% inflation over 27 years. **Funding mechanism:** Project's annual budget/operating revenue
Compliance Monitoring	$182,361	$1,793,149	Interval monitoring (n=7) for estimating take and effectiveness of the turbine operational strategy; includes monitoring logistics, reporting, and agency meetings, with 3% inflation over 27 years. **Funding mechanism:** Project's annual budget/operating revenue
Crop Clearing for Compliance Monitoring	$125,204	$1,231,124	Costs for clearing crops from search areas in monitoring years, with 3% inflation over 27 years. **Funding mechanism:** Project's annual budget/operating revenue
Bias Trials	$13,153	$86,095	Bias trials prior to monitoring years (n=4), with 3% inflation over 27 years. **Funding mechanism:** Project's annual budget/operating revenue
Total Recurring Costs		**$3,273,207**	**See above.**
Non-Recurring Costs			
Wind Cave Gating	n/a	$134,617	Winter mitigation project to offset impact of the requested take for the HCP; includes mitigation project management, monitoring, and reporting. **Funding mechanism:** Executed contract with mitigation entity.
Summer/Swarming Habitat Mitigation Project	n/a	$1,478,200	Anticipated cost of a summer mitigation project to offset impact of the requested take for the HCP; includes mitigation project management, monitoring, and reporting. **Funding mechanism:** Executed contract with mitigation entity.
Changed Circumstances Fund	n/a	$80,640	Additional consultation and monitoring/ evaluation or mitigation necessary to respond to one changed circumstance equivalent to 5% of initial mitigation costs, due to low likelihood of occurrence, low likelihood of large-scale habitat destruction, implementation of all mitigation contracts upfront, and the obligation to offset remaining impact of take at the time of the changed circumstance. **Funding mechanism:** Bond/guaranty from Surety.
Total Non-Recurring Costs		**$1,693,457**	**See above.**

n/a = not applicable

Other costs incurred by the Project include:

- Minimization Measures – The Applicant will implement a turbine operations protocol that is intended to reduce potential impacts to the Covered Species by limiting turbine rotation during periods when the Covered Species are considered at risk, or during the spring, summer, and fall seasons during nighttime conditions of low wind speeds and warm temperatures (Section 5.2.2). The lost revenue associated with these operational adjustments will be absorbed in the annual operation and maintenance budgeting process and is therefore not included as a recurring cost of the HCP.
    - As described in Section 5.2.1, other measures to avoid and minimize take were implemented during Project design and planning. Costs associated with these measures were included, and paid for, as part of the Project development budget prior to the commercial operation of the Project. These costs are not included as non-recurring costs of the HCP because no further funding requirements for Project design and planning measures are anticipated.

7.0 ALTERNATIVES CONSIDERED

The ESA implementing regulations and USFWS guidance for developing HCPs require that an HCP submitted in support of an ITP application must detail among other things, “actions the applicant considered as alternatives to the take that would result from the proposed action and the reasons why they are not using those alternatives” (USFWS and NMFS 2016, page 5-6). The HCP Handbook clarifies that the applicant should focus on alternatives constituting significant differences in project design that would avoid or reduce take. In evaluating potential alternatives, the ESA § 10(a)(2)(B)(ii) provides that the USFWS shall issue an ITP if, among other things, it finds that “the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such [incidental] taking.” Because the Project is already constructed and operating, the only alternative available to avoid take of the Covered Species at the Project would be long-term operation under turbine operational adjustments recommended by the USFWS for avoiding take of these species during the bat active period. The Project could also be shut-down at night during the bat active period, or shut-down entirely, but these alternatives are more onerous than long-term operation under an avoidance strategy and therefore were not considered. The Project could also implement operational minimization plans either more or less restrictive than the proposed operational minimization plan (Table 4.3), but these alternatives either do not offer enough protection to the Covered Species or, like long-term operational adjustments at USFWS recommended “avoidance levels” during the active bat period, the Project would become economically unfeasible and the renewable energy production of the Project would be forgone. Therefore, these alternatives were not considered.

Under the avoidance alternative, Project turbines would be fully feathered at wind speeds below 6.9 m/s from a half hour before sunset to a half hour before sunrise during the bat migration seasons (April 1-May 15 and August 1-October 15) at all turbines and during the bat summer maternity season (May 16-July 31) at the ten turbines determined to have potential summer occurrence of the Covered Species. With the Project implementing these turbine operational adjustments, or alternate measures that may be deemed effective during the permit term, the USFWS would not consider the likelihood of taking Indiana bats or northern long-eared bats to be sufficiently high to warrant incidental take authorization under the ESA (i.e., take would be considered unlikely). Because take of the Covered Species would be unlikely, an ITP would not be issued and the HCP would not be implemented.

This alternative was not selected because it would not meet the purpose and need for the Project and it would result in a financially unviable Project that could not be carried forward. The purpose of the Project is to maximize energy production using reliable sources of wind energy. The need for the Project is the Project's energy contributions to the advancement of national renewable energy objectives which includes generation of enough electricity to power more than 51,000 average Indiana homes with clean energy each year. The Project will also improve local economic opportunities, while minimizing short- and long-term environmental impacts associated with greenhouse gas emissions and carbon output from non-renewable sources of energy production. The Project precludes the emission of many tons of carbon dioxide (CO_2), a contributor to climate change; nitrogen oxide, which causes smog; and sulfur dioxide, which causes acid rain. The annual environmental benefits of the 332,000 tons of CO_2 not emitted due to the Project's clean energy generation are equivalent to taking approximately 183,000 cars off of the road.

The Project contributes significant economic benefits to the surrounding community in the form of payments to landowners, local spending, and annual community investment. The development, construction, and operation of the Project also generated more than 250 jobs at the peak of construction and created 14 full-time, permanent jobs in the area. The Project helps provide energy security to the US by diversifying the electricity generation portfolio, protecting against volatile natural gas spikes, and utilizing a renewable, domestic source of energy.

Under the avoidance alternative, the Project would be economically unfeasible and the renewable energy production of the Project would be forgone. The Project would not contribute to the national renewable energy objectives and contracts for purchase of the Project's energy would not be fulfilled. Additionally, the Project would fail to provide economic benefit to local economies. Jobs associated with maintenance of the Project would be lost and participating landowners would not receive income from lease agreements over the expected life of the Project.

In summary, because the environmental benefits of renewable energy and the economic rewards to local communities would be foregone should the Project become economically unfeasible, the avoidance alternative was not considered further in favor of the proposed action-implementation of the Project under an ITP in accordance with this HCP.

8.0 HABITAT CONSERVATION PLAN ADMINISTRATION

8.1 Habitat Conservation Plan Implementation and Other Such Measures that the Secretary May Require

An expected mandatory condition of the requested ITP will be the requirement that the Applicant implement this HCP for the duration of the ITP term. The Applicant will be solely responsible for implementing the measures described in this HCP and meeting the terms and conditions of the requested ITP. Additionally, the Applicant will allocate sufficient personnel and resources to ensure effective implementation of the HCP and coordination with the USFWS during the Permit term.

To ensure proper implementation of the HCP, the Applicant may designate an HCP Coordinator. The role of the HCP Coordinator will be to oversee the HCP implementation; plan and coordinate meetings with the USFWS or IDNR; organize training of management and O&M staff; oversee allocation of funding for mitigation, monitoring, adaptive management, and changed circumstances, if necessary; and ensure delivery of monitoring reports to the USFWS.

8.2 Changed Circumstances

Under the USFWS's regulations, "changed circumstances" are those "changes in circumstances affecting a species or geographic area covered by a conservation plan or agreement that can reasonably be anticipated by plan or agreement developers and the Service and that can be planned for" (50 CFR 17.3). As described in the HCP Handbook, with respect to foreseeable changed circumstances, the HCP should discuss measures developed by the applicant to address such changes over time, possibly by incorporating adaptive management measures as necessary for the covered species in the HCP. To the extent practicable, the applicant should identify potential problems in advance and identify specific strategies or responses in the HCP for addressing them, so that adjustments can be made as necessary without the need to amend the HCP.

The Applicant believes the following are foreseeable changed circumstances warranting planning considerations:

- Change in Covered Species' migration dates;
- WNS impacts to Covered Species populations are greater than anticipated;
- Listing of additional species, such as little brown bat;
- New technology or information that improves monitoring mortality, estimating mortality, and/or minimizing mortality;
- Changes in mitigation project viability;
- Change in summer risk for Covered Species.

Pursuant to the “No Surprises” Rule (63 FR 8859), if the USFWS determines that additional conservation and mitigation measures are necessary and they have been addressed in this HCP, implementation is required (50 CFR 17.22(b)(5)(i)). If the USFWS determines that additional conservation and mitigation measures are necessary, but they were not provided for in the HCP, such conservation and mitigation measures will not be required of a permittee without its consent (50 CFR 17.22(b)(5)(ii)). If additional measures are deemed necessary to respond to an unforeseen circumstance, additional conservation and mitigation measures will not involve the commitment of additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources without the consent of the permittee (50 CFR 17.22(b)(5)(iii)).

8.2.1 Change in Covered Species Migration Dates

Climate change is ongoing, and effects on species are considered reasonably foreseeable and may potentially influence the phenology of migratory species. This could result in changes in the timing of spring and fall migration of the Covered Species. For example, warmer temperatures may allow Indiana bats and northern long-eared bats to leave hibernacula earlier and remain in summer habitat longer, pushing the dates of spring migration earlier in the year and the dates of fall migration later in the year.

In the event that the timing of Covered Species’ spring and/or fall migration changes due to increased seasonal temperatures, the timing of Covered Species’ mortality at the Project could change, warranting a response by the Applicant.

8.2.1.1 Trigger

(1) USFWS notifies the Applicant of the documentation of a shift in the timing of Covered Species’ spring or fall migration in Indiana, either in peer-reviewed literature or recorded by/reported to the USFWS; or

(2) The carcass of a Covered Species is discovered incidentally at the Project during the early spring or late fall seasons.

8.2.1.2 Response

(1) The Applicant will evaluate the distribution of bat carcasses within the monitoring period to determine if the distribution indicates the spring or fall bat mortality peak has shifted in the season within the Permit Area. Mortality of all bats, including incidental finds, will be used to evaluate this changed circumstance because it is not expected that take of the Covered Species, which may never be documented, will provide sufficient data to assess trends in seasonal distribution. All insectivorous bats migrating through the Permit Area, including the Covered Species, are likely to respond to similar factors affecting the timing of seasonal movements, including temperature and insect availability.

If, over the two most recent monitoring years, a greater proportion of bat carcasses have been found during the first two weeks of the spring season or the last two weeks of the fall season than in any other 2-week period during these seasons or was found during the first three years of intensive monitoring, the Applicant will shift the timing of the minimization and monitoring period in response to the changed circumstance. This shift will be a movement of the entire minimization and monitoring period to earlier or later in the season, rather than an expansion of the period, unless the recent (within 10 years) seasonal distribution of bat carcasses at the Project[25] indicate the migration period has expanded or contracted (i.e., the temporal distribution of carcasses is broader or narrower than six weeks in the spring or 11 weeks in the fall) – in this case, the minimization and monitoring period would be expanded or contracted accordingly. The Applicant will then feather all turbines at wind speeds below 3.5 m/s during the redefined season of spring migratory risk and/or at wind speeds below 5.0 m/s during the redefined season of fall migratory risk from a half hour before sunset to a half hour after sunrise when temperatures are above 10°C. If either or both minimization protocols have been modified as the result of adaptive management, the modified protocol(s) will be implemented.

(2) If a Covered Species fatality is discovered in early spring or late fall, the Applicant will notify the USFWS within 24 hours of positive identification. The Applicant will shift the timing of the minimization and monitoring period to encompass the date(s) of the estimated time of death of the carcass in response to the changed circumstance. This shift will be a movement of the entire minimization and monitoring period to earlier or later in the season, rather than an expansion of the period, unless the timing of any other recent (within 10 years) Covered Species fatalities at the Project[26] indicate the migration period has expanded or contracted rather than shifted (i.e., the temporal distribution of carcasses is broader or narrower than six weeks in the spring or 11 weeks in the fall) – in this case, the minimization and monitoring period would be expanded or contracted accordingly. The Applicant will then feather all turbines at wind speeds below 3.5 m/s during the redefined season of spring migratory risk or at wind speeds below 5.0 m/s during the redefined season of fall migratory risk from a half hour before sunset to a half hour after sunrise when temperatures are above 10°C. If either or both minimization protocols have been modified as the result of adaptive management, the modified protocol(s) will be implemented.

[25] Data from other wind energy facilities in the region or Covered Species migration research studies may also be considered in determining the response, as appropriate.
[26] Data from other wind energy facilities in the region or Covered Species migration research studies may also be considered in determining the response, as appropriate.

8.2.2 White-Nose Syndrome Impacts are Greater than Anticipated

It is difficult to predict at this time what the long-term effects of WNS will be for *Myotis* populations in Indiana and the MRU. If WNS should reduce the population of either Covered Species to the extent that the take permitted in this HCP threatens to have a significant population effect, and in the worst-case scenario, jeopardize that species, then the Applicant will evaluate this changed circumstance with respect to the impact of the permitted level of take. The Applicant will also evaluate the likelihood that the take level has already been reduced because there are fewer bats of the Covered Species on the landscape. At the end of each regular cave survey season, the Applicant will coordinate with the USFWS to evaluate whether or not this trigger has been met. The Applicant will require that the relevant survey results are presented that justify any positive conclusion that the trigger has been met.

8.2.2.1 Trigger

USFWS notification that WNS impacts are more severe than anticipated, to the point that the authorized take level threatens to have a significant population effect and is likely to lead to jeopardy of the Covered Species. This determination will be based on cave counts, hibernaculum emergence surveys, and any other relevant data, such as population viability analyses.

8.2.2.2 Response

The Applicant will work with the USFWS to determine, using the Erickson et al. (2014) or the USFWS-endorsed model at the time, what level of reduced take would cease to result in significant population impacts under scenarios modeled with the observed WNS impacts. The ITP would be adjusted to this level of reduced take for the duration of the permit term, unless cave surveys show that, at some point in the future, WNS impacts lessen to the levels under which the impact of take was originally evaluated for the Project. In that case, the Applicant would again work with the USFWS to determine, using the Erickson et al. (2014) or the USFWS-endorsed model at the time, if the take level can be restored to the original permitted level without resulting in significant population effects or a risk of jeopardy under scenarios modeled with the new observed WNS impacts.

Once the permitted take level has been adjusted, the Applicant will conduct an analysis, in coordination with the USFWS, to determine the appropriate course of action. The analysis will evaluate whether the cumulative level of take reported for the Project to date is on track with the permitted level of take, or whether the cumulative level of take lags behind the permitted level of take (as a decrease in take may be reasonably expected to occur with decreasing Covered Species populations). In addition to site-specific data, research regarding Indiana bat and northern long-eared bat risk at wind energy facilities and existing mortality data for the species, as available, will be considered in the analysis. If the cumulative level of take is found to be low, already in compliance with the adjusted ITP, the Applicant will continue to implement the minimization measures in Section 5.2.2 and monitor mortality as described in Section 5.4.1. If the cumulative level of take is found to be on track to exceed the adjusted permitted level of take, the Applicant will determine, in coordination with USFWS, how the HCP's minimization measures need to be adjusted to maintain take of the Covered Species below the adjusted permitted level.

Examples of adjustments to the HCP minimization measures that may be considered include changes in the turbine cut-in wind speed or temperature for part or all of the Project's turbines, changes in timing of the seasonal turbine operational adjustment period, and deployment of bat deterrent technology, if suitable technology is available.

8.2.3 Additional Species Listings

As a result of current population declines due primarily to WNS, other bat species (such as little brown bat) may become listed under the ESA as threatened or endangered during the term of the requested ITP. Other wildlife species may also become listed under the ESA as threatened or endangered during the term of the ITP due to the impacts of climate change, habitat loss, or other factors. Therefore, the Applicant believes listing of a new bat species or other species of wildlife constitutes a foreseeable changed circumstance that warrants consideration in this HCP.

8.2.3.1 Trigger

USFWS notification of a proposed rule to list under the ESA any bat species or other species of wildlife that may occur in the Permit Area but is not covered by the HCP will trigger a response by the Applicant.

8.2.3.2 Response

The Applicant will evaluate data from all monitoring years up to the time of the proposed rule, and additional scientific information related to the impacts of wind turbines on the species proposed for listing, to determine if take of the species has occurred, or is likely to occur, and determine if the Covered Activities may result in future take of the species proposed for listing. In the event that take has been documented, or it is likely to occur, the Applicant will coordinate with the USFWS. If the species is listed in the final rule, an amendment to the HCP (see Section 8.4.2) will be prepared that includes an assessment of take and impacts of the take evaluation and any additional conservation measures provided for the newly listed species. In the interim, the Applicant will take measures to ensure prohibited take of the newly listed species is not likely to occur.

Upon notice from the USFWS of such listing(s), the Applicant will coordinate with the USFWS to determine, using the best available data and information at the time, if additional avoidance, minimization, or mitigation strategies beyond those implemented for the Covered Species are advisable.

8.2.4 New Technology and Information

Over the ITP term, new information on the Covered Species and bat/wind-power interactions is likely to become available, new methods for monitoring and/or estimating mortality are likely to be developed, and new technology may be developed to minimize bat mortality from wind turbines. The Applicant may wish to incorporate new information, methods, and/or technology into the operations and monitoring plans outlined in the HCP. For example, it is expected that over time, results of post-construction monitoring and research related to bat/wind-power interactions will be useful in determining changes to improve the minimization measures for the Project. New methods, procedures, or analysis for monitoring studies are likely to be developed during the course of the ITP that provide more accurate results for determining the appropriate Project management actions (e.g., adjusting the turbine operations) to minimize impacts.

Currently, ongoing studies addressing the influence of weather conditions on bat mortality may inform improved operation of turbines to meet the HCP biological goals and objectives and increase Project output. In addition, studies and research on the Covered Species are likely to provide useful information related to location, timing, and characteristics of migration or periods when risk is elevated; such information could inform mortality estimates and maximally efficient curtailment conditions for minimizing take at the Project. Deterrent technologies (e.g., acoustic deterrents, visual deterrents) are also being investigated and new advances may make these technologies effective at avoiding or minimizing take while also improving Project productivity. Ideally, these types of technological advances and new information will be used to improve the ability to estimate mortality and maximize the effectiveness of the minimization and monitoring measures associated with the Project and this HCP.

8.2.4.1 Trigger

The Applicant will notify the USFWS of the intent to utilize alternative monitoring, mortality estimation, or minimization methods that have been demonstrated, based on the best available science, to be as effective as or more effective than the methods described in this HCP. New methods (or technologies) will only be considered if they have been demonstrated to be at least as effective as the methods in this HCP, are considered the best available science, will not require an increase in the take authorization for the Project, are cost effective, and are approved by the USFWS.

8.2.4.2 Response

Prior to implementing any new measures for monitoring, estimating mortality, or minimizing take, the Applicant will meet and confer with the USFWS to discuss the new methods, how they will be implemented, and any special conditions that may be needed. The Applicant will work with the USFWS to ensure that any new methods (or technologies) that are used are compatible with the biological goals and objectives of the HCP. Any changes to the minimization methods will result in at least one additional year of Evaluation Phase monitoring (if needed, to be determined) to confirm the effectiveness of the new methods. The monitoring study plan will be determined in consultation with, and approved by, the USFWS.

8.2.5 Change in Mitigation Project Viability

The mitigation projects are intended to provide long-term protection of and reduce threats to maternity habitat and winter habitat for the Covered Species. The expectation is that the mitigation project sites will provide secure habitat for the Covered Species, as well as other bat species, for the life of the requested ITP. This changed circumstance addresses the unlikely potential for the mitigation projects to fail to offset the impacts of take of the Covered Species due to the impact of a natural disaster, such as a drought, flood, storm (including tornadoes), or fire, on the habitat quality of the site.

Based on current conditions and the characteristics of the mitigation projects under consideration, it is anticipated that the selected mitigation projects will more than offset the impact of take for the Covered Species by protecting the integrity of secure, suitable habitat. However, in the event that a natural disaster destroys all or part of the habitat at any of the mitigation sites, the ability of the mitigation projects to offset the take may be compromised. In coordination with the USFWS, the Applicant will evaluate the results of the mitigation project assessments scheduled to occur after implementation of each of the mitigation projects to determine whether the habitat remains suitable for the Covered Species. The Applicant will also work with the USFWS to conduct a site visit and a habitat assessment to determine the status of the impacted mitigation projects within three months of becoming aware (e.g., from the USFWS or other parties) that a natural disaster is likely to have impacted one or more of the mitigation sites.

8.2.5.1 Trigger

Assessment results indicate that one or more of the mitigation sites no longer provide a sufficient amount of suitable habitat to mitigate the remaining impact of take of the Covered Species.

8.2.5.2 Response

Within three months of conducting a site visit to assess the status of the impacted mitigation project(s), the Applicant will coordinate with the USFWS to calculate the remaining amount of take (i.e., the impact of any take projected to occur over the remainder of the ITP term that was not already offset by the mitigation project); this calculation will be based on monitoring data results and the REA model. The Applicant will then work with the USFWS to evaluate potential options for offsetting the remaining amount of take. These options may include: 1) restoration of the mitigation project; 2) purchase of credits (in the amount of the remaining take) from a conservation bank; 3) contribution to WNS remediation effort(s); 4) contribution to bat conservation fund(s); or 5) securement of an additional mitigation project to offset the remaining amount of take. The first four, preferred options, would be implemented by the Applicant within one year of agreement upon the option with the USFWS. The fifth option may require more time to implement due to the logistics of identifying and securing mitigation projects; the Applicant would begin the process of identifying mitigation projects within one year of agreement upon the option with the USFWS, with the goal of securing a mitigation project within two years of agreement with the USFWS.

8.2.6 Change in Summer Risk for the Covered Species

A subset of 10 Project turbines are expected to have a measurable risk of take of the Covered Species during the summer season (May 16 - July 31) and this take is accounted for in the take predictions for the HCP (Sections 4.1.2 and 4.2.2). Because the risk of summer take at the other 90 Project turbines is considered immeasurable at this time based on the best available scientific information for the Project, if take occurs at one of the other 90 turbines during summer, it will be considered a changed circumstance and addressed as described below.

8.2.6.1 Trigger

The carcass of a Covered Species is discovered incidentally at one of the 90 Project turbines with previously immeasurable risk of take during the summer season (May 16 - July 31).

8.2.6.2 Response

The recorded take will be addressed as covered under the ITP; the bat will be added to the HCP's cumulative take estimate and applied against the total authorized take remaining on the ITP. The turbine at which the carcass was found will immediately be operated according to the summer minimization and monitoring measures at the time (i.e., the measures described in Sections 5.2.2 and 5.4.1, as modified by any adaptive management). The Applicant will then re-evaluate the extent of the summer risk of take at the Project by conducting an updated habitat assessment and/or presence-absence surveys as soon as logistically feasible after the take is recorded. Using the results of the re-evaluation, the Applicant will determine the new set of Project turbines with a measurable risk of take and apply the summer minimization and monitoring measures at the time to those turbines.

Based on the quantified risk of summer take at these turbines, the Applicant will assess whether an ITP amendment is needed to cover the additional take. This assessment will consider (1) the updated annual take prediction for the Covered Species, (2) the cumulative take estimate from compliance monitoring to date, and (3) the amount of take authorization remaining on the ITP. If the updated annual take prediction for the Covered Species, projected for the remaining years on the ITP, indicates that take will exceed the amount of take authorization remaining on the ITP, the Applicant will pursue an ITP amendment. The Applicant will include the methods, results, and conclusions of the summer risk re-evaluation and the take assessment in the monitoring report to the USFWS (Section 5.4.4); if the carcass is found in a year without standardized compliance monitoring, the Applicant will submit this information in an interim report to the USFWS by January 31.

8.3 Unforeseen Circumstances

Unforeseen circumstances are defined as changes in circumstances affecting a species or geographic area covered by an HCP that could not reasonably have been anticipated by the permittee and the USFWS at the time of the development of the HCP, and that result in a substantial and adverse change in the status of a covered species (50 CFR 17.3). The USFWS bears the burden of demonstrating that unforeseen circumstances exist and must use best available scientific and commercial data in evaluating unforeseen circumstances (50 CFR 17.22(b)(5)(iii)(C) and 50 CFR 17.32(b)(5)(iii)(C)).

In deciding whether unforeseen circumstances exist which might warrant additional mitigation from an HCP permittee, according to the HCP Handbook, the USFWS shall consider, but not be limited to, the following factors: a) size of the current range of the affected covered species, b) percentage of range adversely affected by the HCP, c) percentage of range conserved by the HCP, d) ecological significance of that portion of the range affected by the HCP, e) level of knowledge about the affected species and the degree of specificity of the species' conservation program under the HCP, f) whether the HCP was originally designed to provide an overall net benefit to the affected species and contained measurable criteria for assessing the biological success of the HCP, and g) whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild (USFWS and NMFS 2016, page 9-40).

If unforeseen circumstances arise, the USFWS will not require the permittee to commit additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources otherwise available for development or use under the original terms of the HCP and beyond the level otherwise agreed upon for the species covered by the HCP without the consent of the permittee (50 CFR 17.22(b)(5)(iii)(A)). If additional conservation and mitigation measures are deemed necessary to respond to unforeseen circumstances, the USFWS may require additional measures of the permittee where the HCP is being properly implemented only if such measures are limited to modifications within conserved habitat areas, if any, or to the HCP's operating conservation program for the affected species, and maintain the original terms of the HCP to the maximum extent possible (50 CFR 17.22(b)(5)(iii)(B)). Additional conservation and mitigation measures will not involve the commitment of additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources otherwise available for development or use under the original terms of the HCP without the consent of the permittee.

Notwithstanding these assurances, nothing in the "No Surprises" Rule (63 FR 8859) "will be construed to limit or constrain the [USFWS], any Federal agency, or a private entity, from taking additional actions, at its own expense, to protect or conserve a species included in [an HCP]" (50 CFR 17.22(b)(6)).

8.4 Permit Amendment

The HCP Handbook indicates that an ITP should be amended when the permittee significantly modifies the covered activities, the project, or the minimization or mitigation measures from the description in the original HCP. Such modifications may include changes in the Permit Area, changes in funding, addition of species to the ITP that were not addressed in the original HCP, or adjustments to the HCP due to strategies developed to address unforeseen circumstances. Depending on the circumstances, these could be made without a formal amendment request, or may require a formal amendment accompanied by public notice and analyses to varying extents, as described below. Any permit amendment must satisfy ESA § 10 review requirements; as the scale and scope of an amendment increases, other responsibilities, such as additional NEPA or ESA § 7 review, may be triggered (USFWS and NMFS 2016, page 17-7).

8.4.1 Changes Made Without a Formal Amendment Request

Some changes or corrections to this HCP or the requested ITP may be agreed upon between the Applicant and the USFWS without a formal amendment request. These changes are primarily corrective revisions where the take levels and project activities are not substantively altered, and may include things like: correcting insignificant mapping errors, slightly modifying avoidance and minimization measures, modifying annual reporting protocols, making small changes to monitoring protocols, making changes to funding sources, and changing the names or addresses of responsible officials (USFWS and NMFS 2016, page 17-7). These changes may be made through an exchange of written correspondence between the Applicant and the USFWS – for example, the Applicant may submit a letter to the USFWS explaining a proposed change, and the USFWS may respond with a letter approving of the change. USFWS-approved changes will be documented in a note to the Project file.

8.4.2 Formal Amendments

Amendments may constitute an exchange of formal correspondence between the USFWS and the Applicant, addenda to the HCP, revisions to the HCP, or ITP amendments. The extent of NEPA and ESA § 7 analyses and public notice processes accompanying an amendment is determined by the USFWS and depends on the scale and scope of the amendment. Amendments that do not increase the levels of incidental take and do not change the covered activity in ways that were not analyzed in the original NEPA or ESA § 7 documents do not usually require advertising for public notice or additional analysis under NEPA or ESA § 7. Amendments that require ITP amendment and publication in the Federal Register include: addition of new species, either listed or unlisted, increased level or different form of take for covered species, changes to funding that affect the ability of the permittee to implement the HCP, changes to covered activities not previously addressed, changes to covered lands, and significant changes to the conservation strategy, including changes to the mitigation measures (USFWS and NMFS 2016, page 17-7).

8.5 Permit Renewal

The Applicant requests that the ITP associated with this HCP be renewable pursuant to 50 CFR § 13.22. In the event that the Applicant plans to continue to operate the Project after the permit term and the cumulative take documented for the Project is less than the take level authorized in the ITP, the Applicant will file in writing a renewal request at least 30 days prior to the permit expiration. Per the HCP Handbook, the USFWS will honor the No Surprises assurances as much as practicable, but a renewed permit must satisfy applicable statutory and regulatory requirements in force as of the date of the approval of the renewal request. Permit renewals must be published in the Federal Register before the USFWS issues a decision, even if there are no revisions (USFWS and NMFS 2016, page 17-8).

9.0 REFERENCES

9.1 Literature Cited

Amelon, S. and D. Burhans. 2006. Conservation Assessment: *Myotis leibii* (Eastern Small-Footed Myotis) in the Eastern United States. *In:* US Department of Agriculture (USDA) Forest Service General Technical Report NC-260: Conservation Assessments for Five Forest Bat Species in the Eastern United States.

Arnett, E. B., W. P. Erickson, J. Kerns, and J. Horn. 2005. Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. Final Report. Prepared for Bats and Wind Energy Cooperative, Bat Conservation International, Austin, Texas. June 2005. Available online at: http://www.batsandwind.org/pdf/ar2004.pdf

Arnett, E. B., K. Brown, W. P. Erickson, J. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal of Wildlife Management 72(1): 61-78.

Arnett, E. B., M. M. P. Huso, M. R. Schirmacher, and J. P. Hayes. 2010. Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities: Final Report. Annual report prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. Bat Conservation International (BCI), Austin, Texas. May 2010. Available online at: http://www.batsandwind.org/pdf/Curtailment%20Final%20Report%205-15-10%20v2.pdf

Arnett, E. B., G. D. Johnson, W. P. Erickson, and C. D. Hein. 2013. A Synthesis of Operational Mitigation Studies to Reduce Bat Fatalities at Wind Energy Facilities in North America. A report submitted to the National Renewable Energy Laboratory (NREL), Golden Colorado. Bat Conservation International (BCI), Austin, Texas. March 2013.

Arnold, B. D. 2007. Population Structure and Sex-Biased Dispersal in the Forest-Dwelling Vespertilionid Bat, *Myotis septentrionalis*. American Midland Naturalist 157: 374-384.

Avery, M. I. 1985. Winter Activity of Pipistrelle Bats. Journal of Animal Ecology 54(3): 721-738.

Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. R. Barclay. 2008. Barotrauma Is a Significant Cause of Bat Fatalities at Wind Turbines. Current Biology 18(16): R695-R696.

Baerwald, E. F., J. Edworthy, M. Holder, and R. M. R. Barclay. 2009. A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities. Journal of Wildlife Management 73(7): 1077-1081.

Barbour, R. A. and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington, Kentucky. 286 pp.

Barclay, R. M. R. and L. D. Harder. 2005. Life Histories of Bats: Life in the Slow Lane. Pp. 209-253. *In*: T. Kunz and M. B. Fenton, eds. Bat Ecology. The University of Chicago Press, Chicago and London.

Barclay, R. M. R. and A. Kurta. 2007. Ecology and Behavior of Bats Roosting in Tree Cavities and under Bark. Pp. 17-59. *In*: M. J. Lacki, J. P. Hayes, and A. Kurta, eds. Bats in Forests: Conservation and Management. John Hopkins University Press, Baltimore, Maryland.

Barclay, R. M. R., J. Ulmer, C. J. A. MacKenzie, M. S. Thompson, L. Olson, J. McCool, E. Cropley, and G. Poll. 2004. Variation in Reproductive Rate of Bats. Canadian Journal of Zoology 82: 688-693.

Blehert, D. S., A. Hicks, M. Behr, C. U. Meteyer, B. Berlowski-Zier, E. Buckles, J. D. Coleman, S.R., A. Gargas, R. Niver, J. Okoniewski, R. Rudd, and W. B. Stone. 2009. Bat White-Nose Syndrome: An Emerging Fungal Pathogen? Science 323: 227.

Blehert, D. S., J. M. Lorch, A. E. Ballmann, P. M. Cryan, and C. U. Meteyer. 2011. Bat White-Nose Syndrome in North America. Microbe 6(6): 267-273.

Boyles, J. G., J. J. Storm, and V. Brack. 2008. Thermal Benefits of Clustering During Hibernation: A Field Test of Competing Hypotheses on *Myotis sodalis*. Functional Ecology 22: 632-636.

Boyles, J. G., J. C. Timpone, and L. W. Robbins. 2009. Bats of Missouri. Indiana State University Center for North American Bat Research and Conservation, Publication Number 3. Indiana State University Press, Terre Haute, Indiana.

Brack, V. Jr., C. W. Stihler, R. J. Reynolds, C. M. Butchkoski, and C. S. Hobson. 2002. Effect of Climate and Elevation on Distribution and Abundance in the Mideastern United States. Pp. 21-28. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Brack, V. Jr. 2004. Field Techniques for Biological Assessment: Assessment of Potential Hibernacula and Swarming/Staging Habitat. Pp. 89-92. *In*: K. C. Vories and A. Harrington, eds. Indiana Bat and Coal Mining: A Technical Interactive Forum. US Department of Interior, Office of Surface Mining, Alton, Illinois Coal Research Center, Southern Illinois University, Carbondale, Illinois, Louisville, Kentucky.

Brack, V. Jr. 2006. Autumn Activity of *Myotis sodalis* (Indiana Bat) in Bland County, Virginia. Northeastern Naturalist 13: 421-434.

Britzke, E. R. 2003. Spring Roosting Ecology of Female Indiana Bats (*Myotis sodalis*) in the Northeastern United States. US Fish and Wildlife Service (USFWS), New England Field Office, Concord, New Hampshire.

Britzke, E. R., A. C. Hicks, S.L. von Oettingen, and S. R. Darling. 2006. Description of Spring Roost Trees Used by Female Indiana Bats (*Myotis sodalis*) in the Lake Champlain Valley of Vermont and New York. American Midland Naturalist 155: 181-187.

Broders, H. G. and G. J. Forbes. 2004. Interspecific and Intersexual Variation in Roost-Site Selection of Northern Long-Eared and Little Brown Bats in the Greater Fundy National Park Ecosystem. Journal of Wildlife Management 68(3): 602-610.

Broders, H. G., G. J. Forbes, S. Woodley, and I. D. Thompson. 2006. Range Extent and Stand Selection for Roosting and Foraging in Forest-Dwelling Northern Long-Eared Bats and Little Brown Bats in the Greater Fundy Ecosystem, New Brunswick. Journal of Wildlife Management 70: 1174-1184.

Brooks, R. T. 2010 Declines in Summer Bat Activity in Central New England 4 Years Following the Initial Detection of White-Nose Syndrome. Biodiversity and Conservation 20(11): 2537-2541.

Brooks, R. T. and W. M. Ford. 2005. Bat Activity in a Forest Landscape of Central Massachusetts. Northeastern Naturalist 12(4): 447-462.

Butchkoski, C. M. and J. D. Hassinger. 2002. Ecology of a Maternity Colony Roosting in a Building. Pp. 130-142. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Butchkoski, C. M. and G. Turner. 2005. Indiana Bat (*Myotis sodalis*) Investigations at Canoe Creek, Blair County, Pennsylvania. Pennsylvania Game Commission. Harrisburg, Pennsylvania.

Butchkoski, C. M. and G. Turner. 2006. Indiana Bat (*Myotis sodalis*) Summer Roost Investigations. Project 06714. Annual job report. Pennsylvania Game Commission, Bureau of Wildlife Management Research Division. Harrisburg, Pennsylvania.

Butchkoski, C. M. and G. Turner. 2008. Indiana Bat (*Myotis sodalis*) Summer Roost Investigations.

Annual job report. Pennsylvania Game Commission. Harrisburg, Pennsylvania.

Butchkoski, C. M., J. Chenger, A. Hicks, and R. Reynolds. 2008. Spring Indiana Bat Migration Telemetry. Presentation at the Joint Meeting of 13th Annual Meeting of the Southeastern Bat Diversity Network, 10th Annual Meeting of the Northeast Bat Working Group, 18th Colloquium on Conservation of Mammals in the Southeastern United States, Blacksburg, Virginia.

Caceres, M. C. and M. J. Pybus. 1997. Status of the Northern Long-Eared Bat (*Myotis septentrionalis*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, Wildlife Status Report No. 3, Edmonton, Alberta.

Caceres, M. C. and R. Barclay. 2000. *Myotis septentrionalis*. Mammalian Species 634: 1-4.

Caire, W., R. K. Laval, M. K. Laval, and R. Clawson. 1979. Notes on the Ecology of *Myotis keenii* (Chiroptera, Vespertilionidae) in Eastern Missouri. American Midland Naturalist 102: 404-407.

Callahan, E. V. 1993. Indiana Bat Summer Habitat Requirements. University of Missouri, Columbia, Missouri. 84 pp. Thesis.

Callahan, E. V., R. D. Drobney, and R. L. Clawson. 1997. Selection of Summer Roosting Sites by Indiana Bats (*Myotis sodalis*) in Missouri. Journal of Mammalogy 78(3): 818-825.

Carter, T. C. and G. A. Feldhamer. 2005. Roost Tree Use by Maternity Colonies of Indiana Bats and Northern Long-Eared Bats in Southern Illinois. Forest Ecology and Management 219: 259-268.

Center for Biological Diversity (CBD). 2010. Petition to List the Eastern-Small Footed Bat *Myotis leibii* and Northern Long-Eared Bat *Myotis septentrionalis* as Threatened or Endangered under the Endangered Species Act. CBD, Richmond, Vermont. Available online at: http://www.biologicaldiversity.org/campaigns/bat_crisis_white-nose_syndrome/pdfs/petition-Myotisleibii-Myotisseptentrionalis.pdf

Clark, B. K., J. B. Bowles, and B. S. Clark. 1987. Summer Status of the Endangered Indiana Bat in Iowa. American Midland Naturalist 118: 32-39.

Cope, J. B. and S. R. Humphrey. 1972. Reproduction of the Bats *Myotis keenii* and *Pipistrellus subflavus* in Indiana. Bat Research News 13: 9-10.

Cope, J. B. and S. R. Humphrey. 1977. Spring and Autumn Swarming Behavior in the Indiana Bat, *Myotis sodalis*. Journal of Mammalogy 58: 93-95.

Cope, J. B., A. R. Richter., and R. S. Mills. 1974. A Summer Concentration of the Indiana Bat, *Myotis sodalis*, in Wayne County, Indiana. Proceedings of the Indiana Academy of Science 83: 482-484.

Cryan, P. M., M. A. Bogan, and G. M. Yanega. 2001. Roosting Habits of Four Bat Species in the Black Hills of South Dakota. Acta Chiropterologica 3: 43-52.

Dalthorp, D. and M. Huso. 2015. A framework for decision points to trigger adaptive management actions in long-term incidental take permits: U.S. Geological Survey Open-File Report 2015-1227, 88 pp. http://dx.doi.org/10.3133/ofr20151227.

Davis, W. H. and H. B. Hitchcock. 1965. Biology and Migration of the Bat, *Myotis lucifugus*, in New England. Journal of Mammalogy 46(2): 296-313.

Dickinson, M. B., M. J. Lacki, and D. R. Cox. 2009. Fire and the Endangered Indiana Bat. Pp. 51-75. *In*: GTR-NRS-P-46. Proceedings of the Third Fire in Eastern Oak Forests Conference.

Dzal, Y., L. P. McGuire, N. Veselka, and M. B. Fenton. 2010. Going, Going, Gone: The Impact of White-Nose Syndrome on the Summer Activity of the Little Brown Bat (*Myotis lucifugus*). Biology Letters 7: doi: 10.1098/rsbl.2010.0859.

Easterla, D. A. 1968. Parturition of Keen's Myotis in Southwestern Missouri. Journal of Mammalogy 49: 770.

Erickson, R.A., W.E. Thogmartin, and J.A. Szymanski. 2014. BatTool: an R package with GUI for assessing the effect of White-nose syndrome and other take events on *Myotis* spp. of bats. Source Code for Biology and Medicine. 9:9.

ESRI. 2016. World Imagery and Aerial Photos. ArcGIS Resource Center. ESRI, producers of ArcGIS software. Redlands, California.

ESRI. 2017. World Street Map. ArcGIS Resource Center. ESRI, producers of ArcGIS software, Redlands, California. Data accessed January 2017. Information available online from: https://www.arcgis.com/home/item.html?id=3b93337983e9436f8db950e38a8629af

Evers, D. C. 1992. A Guide to Michigan's Endangered Wildlife. University of Michigan Press, Ann Arbor, Michigan.

Faure, P. A., J. H. Fullard, and J. W. Dawson. 1993. The Gleaning Attacks of the Northern Long-Eared Bat, *Myotis septentrionalis*, Are Relatively Inaudible to Moths. Journal of Experimental Biology 178: 173-189.

Federal Aviation Administration (FAA). 2000. Obstruction Marking and Lighting. AC 70/7460-1K. Available online at: http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/b993dcdfc37fcdc486257251005c4e21

Federal Aviation Administration (FAA). 2007. Obstruction Marking and Lighting. Advisory Circular. AC 70/7460-1K. US Department of Transportation, FAA. Effective February 1, 2007. Available online at: http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2070%207460-1K.pdf

Fenton, M. B. 1970. Population Studies of *Myotis lucifugus* (Chiroptera: Vespertilionidae) in Ontario. Life Sciences Contributions, Royal Ontario Museum 77: 1-34.

Fleming, T. H. and P. Eby. 2003. Ecology of Bat Migration. Pp. 156-208. *In*: T. H. Kunz and M. B. Fenton, eds. Bat Ecology. University of Chicago Press, Chicago, Illinois.

Ford, W. M., S. F. Owen, J. W. Edwards, and J. L. Rodrigue. 2006. *Robinia Pseudoacacia* (Black Locust) as Day-Roosts of Male *Myotis septentrionalis* (Northern Bats) on the Fernow Experimental Forest, West Virginia. Northeastern Naturalist 13: 15-24.

Foster, R. W. and A. Kurta. 1999. Roosting Ecology of the Northern Bat (*Myotis septentrionalis*) and Comparisons with the Endangered Indiana Bat (*Myotis sodalis*). Journal of Mammalogy 80: 659-672.

Frick, W. F., J. F. Pollock, A. C. Hicks, K. E. Langwig, D. S. Reynolds, G. G. Turner, C. M. Butchkoski, and T. H. Kunz. 2010. An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. Science 329: 679-682.

Gaisler, J., J. Zukal, Z. Rehak, and M. Homolka. 1998. Habitat Preference and Flight Activity of Bats in a City. Journal of Zoology-London 244: 439-445.

Gardner, J. E. and E. A. Cook. 2002. Seasonal and Geographic Distribution and Quantification of Potential Summer Habitat. Pp. 9-20. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Gardner, J. E., J. D. Gardner, and J. E. Hofmann. 1991. Summer Roost Selection and Roosting Behavior of *Myotis sodalis* (Indiana Bat) in Illinois. Final Report. Natural History Survey and Illinois Department of Conservation. Champaign, Illinois. 56 pp.

Good, R. E., W. P. Erickson, A. Merrill, S. Simon, K. Murray, K. Bay, and C. Fritchman. 2011. Bat Monitoring Studies at the Fowler Ridge Wind Energy Facility, Benton County, Indiana: April 13 - October 15, 2010. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. January 28, 2011.

Good, R. E., A. Merrill, S. Simon, K. Murray, and K. Bay. 2012. Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: April 1 - October 31, 2011. Prepared for the Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 31, 2012.

Good. R. E., M. Sonnenberg, and S. Simon, 2013a. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana. Final Report: August 1 – October 15, 2012. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana

Good. R. E., K. Adachi, C. Lebeau, S. Simon, and B. Hale. 2013b. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana. Final Report: August 1 – October 15, 2013. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana.

Good, R.E., J. Gruver, M. Ritzert, T. Sichmeller, and K. Bay. 2014a. Bat Activity Studies for the Headwaters Wind Resource Area, Randolph County, Indiana. Final Report: July 14 – October 18, 2010. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 2, 2014.

Good. R. E., G. Iskali, K. Adachi. 2014b. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana. Final Report: August 1 – October 15, 2014. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana.

Good, R. E., G. Iskali, D. Riser-Espinoza, and K. Adachi. 2015. Post-Construction Monitoring at the Timber Road II Wind Farm, Paulding County, Ohio. Final Report: April 1 - November 15, 2014. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. May 14, 2015.

Good, R. E., G. Iskali, and L.A. Starcevich. 2016a. Post-Construction Studies for the Headwaters Wind Farm, Randolph County, IN. Final Report: March 2015 – October 2015. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. February 10, 2016.

Good. R. E., G. Iskali, K. Nasman. 2016b. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 3 – October 14, 2015. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana.

Good. R. E., A. Ciecka, G. Iskali, and K. Nasman. 2017. Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 3 – October 12, 2016. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana.

Grehan, J. R. 2008. Steel Winds Bird Mortality Study, Final Report, Lackawanna, New York. Prepared for Steel Winds LLC. April 2008.

Griffin, D. R. 1940. Notes on the Life Histories of New England Cave Bats. Journal of Mammalogy 21: 181-187.

Griffin, D. R. 1945. Travels of Banded Cave Bats. Journal of Mammalogy 26: 15-23.

Griffin, D. R. 1970. Migration and Homing of Bats. Pp. 233-264. *In*: W. A. Wimsatt, ed. Biology of Bats. Academic Press, New York.

Gumbert, M. W. 2001. Seasonal Roost Tree Use by Indiana Bats in the Somerset Ranger District of Daniel Boone National Forest, Kentucky. Thesis. Eastern Kentucky University, Richmond, Kentucky,

Gumbert, M. W., J. M. O'Keefe, and J. R. MacGregor. 2002. Roost Fidelity in Kentucky. Pp. 143-152. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Gumbert, M. W., P. Roby, and J. Hawkins. 2011. Spring Migration of Female Indiana Bats (*Myotis sodalis*) from Caves in Eastern Tennessee. 68 pp.

Guthrie, M. J. 1933. The Reproductive Cycles of Some Cave Bats. Journal of Mammalogy 14: 199-216. Hall, J. S., R. J. Cloutier, and D. R. Griffin. 1957. Longevity Records and Notes on Tooth Wear of Bats. Journal of Mammalogy 38(3): 407-409.

Hall, J. S. 1962. A Life History and Taxonomic Study of the Indiana Bat, *Myotis sodalis*. Reading Public Museum and Art Gallery Publication 12: 1-68.

Harvey, M. J. 1992. Bats of the Eastern United States. Arkansas Game and Fish Commission. 46 pp.

Hawkins, J. A., J. Jaskula, A. Mann, and V. Brack, Jr. . 2005. Habitat Conservation Plan: 2004 Telemetry Study of Autumn Swarming Behavior of the Indiana Bat (*Myotis sodalis*). Report prepared for the Indiana Department of Natural Resources, Indianapolis, Indiana. 25 pp. plus.

Hayes, J. P. 1997. Temporal Variation in Activity of Bats and the Design of Echolocation-Monitoring Studies. Journal of Mammalogy 78: 514-524.

Hein, C. D., A. Prichard, T. Mabee, and M. R. Schirmacher. 2013. Effectiveness of an Operational Mitigation Experiment to Reduce Bat Fatalities at the Pinnacle Wind Farm, Mineral County, West Virginia, 2012. Bat Conservation International, Austin, Texas, and ABR, Inc., Forest Grove, Oregon. April 2013.

Hein, C. D., A. Prichard, T. Mabee, and M. R. Schirmacher. 2014. Efficacy of an Operational Minimization Experiment to Reduce Bat Fatalities at the Pinnacle Wind Farm, Mineral County, West Virginia, 2013. Final Report. An annual report submitted to Edison Mission Energy and the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas. February 2014.

Henderson, L. E. and H. G. Broders. 2008. Movements and Resource Selection of the Northern Long-Eared Myotis (*Myotis septentrionalis*) in a Forest-Agriculture Landscape. Journal of Mammalogy 89: 952-963.

Henry, M., D. W. Thomas, R. Vaudry, and M. Carrier. 2002. Foraging Distances and Home Range of Pregnant and Lactating Little Brown Bats (*Myotis lucifugus*). Journal of Mammalogy 83: 767-774.

Hicks, A. 2004. Indiana Bat (*Myotis sodalis*): Protection and Management in New York State. Endangered Species Investigations Performance Report. Prepared for project number W-166-E, Segment 2003-2004, New York Department of Environmental Conservation. 15 pp.

Hicks, A., C. Herzog, and M. Clark. 2005. Indiana Bat (*Myotis sodalis*) Protection and Management in New York State. Annual report on New York Department of Environmental Conservation Activities. 30 pp.

Hicks, A. 2006. Migratory Behavior of Female Indiana Bats in New York and Implications for Wind Development. National Wind Coordinating Collaborative (NWCC) Wildlife Workgroup Research Planning Meeting VI, San Antonio, Texas. November 14-15, 2006.

Hicks, A. C., C. J. Herzog, R.I. von Linden, S. R. Darling, and J. T. H. Coleman. 2008. White Nose Syndrome: Field Observations from the First Two Winters. First Annual White-nose Syndrome Symposium. Albany, New York, June 9-11, 2008. 40 pp.

Hicks, A. C., M. Cooper, W. Skinner, R. V. Linden, A. Bailey, J. A. Kath, and M. Sailor. 2012. Spring Migratory Behavior of Female Indiana Bats (Myotis sodalis) from the Blackball Mine Complex, Lasalle County, Illinois. Final Report prepared by Vesper Environmental LLC, Invenergy LLC, US Fish and Wildlife Service, and the Illinois Department of Natural Resources. Prepared for Invenergy LLC, Chicago, Illinois.

Hitchcock, H. B. 1949. Hibernation of Bats in Southeastern Ontario and Adjacent Quebec. Canadian Field Naturalist 63: 47-59.

Homer, C. G., J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the Conterminous United States-Representing a Decade of Land Cover Change Information. Photogrammetric Engineering and Remote Sensing 81(5): 345-354. Available online from: http://www.mrlc.gov/nlcd2011.php

Horn, J. W., E. B. Arnett, and T. H. Kunz. 2008. Behavioral Responses of Bats to Operating Wind Turbines. Journal of Wildlife Management 72(1): 123-132.

Hoying, K. M. and T. H. Kunz. 1998. Variation in Size at Birth and Post-Natal Growth in the Eastern Pipistrelle Bat *Pipistrellus subflavus* (Chiroptera: Vespertilionidae). Journal of Zoology (London) 245: 15-27.

Humphrey, S. R. and J. B. Cope. 1976. Population Ecology of the Little Brown Bat, *Myotis lucifugus*, in Indiana and North-Central Kentucky. American Society of Mammalogists Special Publication No. 4.

Humphrey, S. R. and J. B. Cope. 1977. Survival Rates of the Endangered Indiana Bat, *Myotis sodalis*. Journal of Mammalogy 58: 32-36.

Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer Habitat and Ecology of the Endangered Indiana Bat, *Myotis sodalis*. Journal of Mammalogy 58(3): 334-346.

Huso, M. M. P., D. Dalthorp, D. Dail, and L. Madsen. 2015. Estimating Wind-Turbine-Caused Bird and Bat Fatality When Zero Carcasses Are Observed. Ecological Applications 25: 1213-1255. doi: 10.1890/14-0764.1.

Huso, M., D. Dalthorp, and F. Korner-Nievergelt. 2017. Statistical Principles of Post-Construction Fatality Monitoring Design. In Perrow, M. (ed) Wildlife and Wind Farms, Conflicts and Solutions, Volume 2, Onshore: Monitoring and Mitigation. Exeter: Pelagic Publishing.

Indiana Department of Natural Resources (IDNR). 2011. Bat Tests Positive for White-Nosed Fungus. IDNR, Indianapolis, Indiana. February 1, 2011. Available online at: https://www.whitenosesyndrome.org/sites/default/files/files/indianawns.pdf

Jacques Whitford Stantec Limited (Jacques Whitford). 2009. Ripley Wind Power Project Postconstruction Monitoring Report. Project No. 1037529.01. Report to Suncor Energy Products Inc., Calgary, Alberta, and Acciona Energy Products Inc., Calgary, Alberta. Prepared for the Ripley Wind Power Project Post-Construction Monitoring Program. Prepared by Jacques Whitford, Markham, Ontario. April 30, 2009.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, A. Fuerst, and C. Hansen. 2009. Annual Report for the Noble Ellenburg Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and A. Harte. 2011. Annual Report for the Noble Wethersfield Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2010. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. January 22, 2011.

James, R. D. 2008. Erie Shores Wind Farm, Port Burwell, Ontario: Fieldwork Report for 2006 and 2007 During the First Two Years of Operation. Report to Environment Canada, Ontario Ministry of Natural Resources, Erie Shores Wind Farm LP - McQuarrie North American and AIM PowerGen Corporation. January 2008.

Johnson, G. D., M. Ritzert, S. Nomani, and K. Bay. 2010a. Bird and Bat Fatality Studies, Fowler Ridge I Wind-Energy Facility Benton County, Indiana. Unpublished report prepared for British Petroleum Wind Energy North America Inc. (BPWENA) by Western EcoSystems Technology, Inc. (WEST).

Johnson, G. D., M. Ritzert, S. Nomani, and K. Bay. 2010b. Bird and Bat Fatality Studies, Fowler Ridge III Wind-Energy Facility, Benton County, Indiana. April 2 - June 10, 2009. Prepared for BP Wind Energy North America. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Kerlinger, P., J. Guarnaccia, L. Slobodnik, and R. Curry. 2011. A Comparison of Bat Mortality in Farmland and Forested Habitats at the Noble Bliss and Wethersfield Windparks, Wyoming County, New York. Report Prepared for Noble Environmental Power. Report prepared by Curry & Kerlinger, LLC, Cape May Point, New Jersey. November 2011.

Kerns, J. and P. Kerlinger. 2004. A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003. Prepared for FPL Energy and the Mountaineer Wind Energy Center Technical Review Committee. February 14, 2004. 39 pp. http://www.wvhighlands.org/Birds/MountaineerFinalAvianRpt-%203-15-04PKJK.pdf

King, A. 1993. A Model of Summer Habitat Use by the Federally Endangered Indiana Bat (*Myotis sodalis*) in Indiana: Compilation of Data from 1990-1992 Field Studies. 3D/Environmental Services Inc., Cincinnati, Ohio. Unpublished Technical Report submitted to the Indiana Department of Natural Resources, Division of Fish and Wildlife, Endangered Species Program.

Kiser, J. D. and C. L. Elliot. 1996. Foraging Habitat, Food Habits, and Roost Tree Characteristics of the Indiana Bat, *Myotis sodalis*, During Autumn in Jackson County, Kentucky. Final report for the Kentucky Department of Fish and Wildlife Resources. 65 pp.

Krochmal, A. R. and D. W. Sparks. 2007. Timing of Birth and Estimation of Age of Juvenile *Myotis septentrionalis* and *Myotis lucifugus* in West-Central Indiana. Journal of Mammalogy 88(3): 649-656.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological Impacts of Wind Energy Development on Bats: Questions, Hypotheses, and Research Needs. In press. Frontiers in Ecology and the Environment 5.

Kurta, A. 1995. Mammals of the Great Lakes Region: Revised Edition. M. M. Douglas, ed. The Great Lakes Environment Series. The University of Michigan Press, Ann Arbor, Michigan. 392 pp.

Kurta, A. 2000. The Bat Community in Northwestern Lower Michigan, with Emphasis on the Indiana Bat and Eastern Pipistrelle. Unpublished report. US Forest Service (USFS), Huron-Manistee National Forests, Cadillac, Michigan.

Kurta, A. 2004. Roosting Ecology and Behavior of Indiana Bats (*Myotis sodalis*) in Summer. Pp. 29-42. *In*: K. C. Vories and A. Harrington, eds. Indiana Bat and Coal Mining: A Technical Interactive Forum. US Department of Interior, Office of Surface Mining, Alton, Illinois Coal Research Center, Southern Illinois University, Carbondale, Illinois. Louisville, Kentucky, Louisville, Kentucky.

Kurta, A. 2005. Roosting Ecology and Behavior of Indiana Bats (*Myotis sodalis*) in Summer. Pp. 29-42. *In*: K. C. Vories and A. Harrington, eds. The Indiana Bat and Coal Mining. Office of Surface Mining, US Department of the Interior, Alton, Illinois.

Kurta, A. and S. W. Murray. 2002. Philopatry and Migration of Banded Indiana Bats (*Myotis sodalis*) and Effects of Radio Transmitters. Journal of Mammalogy 83(2): 585-589.

Kurta, A. and H. Rice. 2002. Ecology and Management of the Indiana Bat in Michigan. Michigan Academician (Papers of the Michigan Academy of Science, Arts, and Letters) 33(3): 361-376.

Kurta, A. and J. A. Teramino. 1994. A Novel Hibernaculum and Noteworthy Records of the Indiana Bat and Eastern Pipistrelle (Chiroptera: Vespertilionidae). American Midland Naturalist 132: 410-413.

Kurta, A., K. J. Williams, and R. Mies. 1996. Ecological, Behavioural, and Thermal Observations of a Peripheral Population of Indiana Bats (*Myotis sodalis*). Pp. 102-117. *In*: R. M. R. Barclay and R. M. Brigham, eds. Bats and Forests. Research Branch, Ministry of Forests, Province of British Columbia, Victoria, British Columbia, Canada.

Kurta, A., S. W. Murray, and D. H. Miller. 2002. Roost Selection and Movements across the Summer Landscape. Pp. 118-129. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Lacki, M. J. 1984. Temperature and Humidity-Induced Shifts in the Flight Activity of Little Brown Bats. Ohio Journal of Science 84: 264-266.

Lacki, M. J. and J. H. Schwierjohann. 2001. Day-Roost Characteristics of Northern Bats in Mixed Mesophytic Forest. Journal of Wildlife Management 65: 482-488.

Lacki, M. J., S. K. Amelon, and M. D. Baker. 2007. Foraging Ecology of Bats in Forests. Pp. 83-127. *In*: M. J. Lacki, A. Kurta, and J. P. Hayes, eds. Conservation and Management of Bats in Forests. Johns Hopkins University Press, Baltimore, Maryland.

Lacki, M. J., D. R. Cox, and M. B. Dickinson. 2009. Meta-Analysis of Summer Roosting Characteristics of Two Species of Myotis Bats. American Midland Naturalist 162: 318-326.

Langwig, K. E., S. R. Darling, W. F. Frick, C. J. Herzog, A. C. Hicks, C. J. Kocer, T. H. Kunz, R. B. Smith, and R.I. von Linden. 2010. Declines of Six Hibernating Bat Species from White-Nose Syndrome in the Northeastern United States. *In*: 2010 White-nose Syndrome Symposium, Pittsburgh, Pennsylvania.

LaVal, R. K. and M. L. LaVal. 1980. Ecological Studies and Management of Missouri Bats with Emphasis on Cave-Dwelling Species. Missouri Department of Conservation Terrestrial Series No. 8: 1-52.

Layne, J. N., ed. 1978. Rare and Endangered Biota of Florida. Vol. 1. Mammals. State of Florida Game and Freshwater Fish Commission. Xx + 52 Pp.

Libby, G. 2013. Indiana Bat (*Myotis sodalis*) Summer Mist Netting Survey, Headwaters Wind Farm, Randolph County, Indiana. Prepared by Skybax Ecological Services, LLC, Berea, Kentucky. August 2013.

Lorch, J. M., C. U. Meteyer, M. J. Behr, J. G. Boyles, P. M. Cryan, A. C. Hicks, A. E. Ballmann, J. T. H. Coleman, D. N. Redell, D. M. Reeder, and D. S. Blehert. 2011. Experimental Infection of Bats with *Geomyces destructans* Causes White-Nose Syndrome. Nature 480: 376-378.

McShea, W. J. and H. Lessig. 2005. Migration of Female Indiana Bats (*Myotis sodalis*) from Winter Hibernacula to Summer Maternity Roost. Draft report to the Virginia Department of Game and Inland Fisheries, Richmond, Virginia.

Miller, G. S. and G. M. Allen. 1928. The American Bats of the Genera *Myotis* and *Pizonyx*. Bulletin of the US National Museum 144: 1-218.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer Habitat in Northern Missouri. Pp. 165-171. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Mills, R. S. 1971. A Concentration of *Myotis keenii* at Caves in Ohio. Journal of Mammalogy 52: 625.

Minnis, A. M. and D. L. Lindner. 2013. Phylogenetic Evaluation of *Geomyces* and Allies Reveals No Close Relatives of *Pseudogymnoascus destructans*, Comb. Nov., in Bat Hibernacula of Eastern North America. Fungal Biology 117: 638-649.

Mumford, R. E. and L. L. Calvert. 1960. *Myotis sodalis* Evidently Breeding in Indiana. Journal of Mammalogy 41: 512.

Murray, K., R. Good, and K. Bay. 2011. Summer Indiana Bat Studies for the Headwaters Wind Resource Area, Randolph County, Indiana. Final Report: May 25-June 17, 2010. Prepared for Horizon Wind Energy, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 26, 2011.

Murray, S. W. and A. Kurta. 2004. Nocturnal Activity of the Endangered Indiana Bat (*Myotis sodalis*). Journal of Zoology (London) 262: 197-206.

Myers, R. F. 1964. Ecology of Three Species of Myotine Bats in the Ozark Plateau. Ph.D. Dissertation. University of Missouri, Columbia, Missouri. 210 pp.

Nagorsen, D. W. and R. M. Brigham. 1993. Northern Long-Eared Myotis (*Myotis septentrionalis*). *In:* Bats of British Columbia. Royal British Columbia Museum Handbook. University of British Columbia Press, Vancouver, British Columbia. 165 pp.

National Geographic Society (National Geographic). 2017. World Maps. Digital Topographic Map. PDF topographic map quads available online from: http://www.natgeomaps.com/trail-maps/pdf-quads

National Renewable Energy Laboratory (NREL). 2012. NRELThinks Big at Wind Technology Center. Accessed October 30, 2012. Online at: www.nrel.gov/news/features/feature_detail.cfm/feature_id=1814

North American Datum (NAD). 1983. NAD83 Geodetic Datum.

O'Shea, T. J., L. E. Ellison, and T. R. Stanley. 2004. Survival Estimation in Bats: Historical Overview, Critical Appraisal, and Suggestions for New Approaches. Pp. 297–336. *In*: W. L. Thompson, ed. Sampling Rare and Elusive Species: Concepts, Designs, and Techniques for Estimating Population Parameters. Island Press, Washington, D.C.

O'Farrell, M. J. and W. G. Bradley. 1970. Activity Patterns of Bats over a Desert Spring. Journal of Mammalogy 51(1): 18-26.

Owen, S. F., M. A. Menzel, W. M. Ford, J. W. Edwards, B. R. Chapman, K. V. Miller, and P. B. Wood. 2002. Roost Tree Selection by Maternal Colonies of Northern Long-Eared Myotis in an Intensively Managed Forest. US Department of Agriculture (USDA) Forest Service, General Technical Report NE-292. USDA Northeastern Research Station, Newtown Square, Pennsylvania.

Owen, S. F., M. A. Menzel, W. M. Ford, B. R. Chapman, K. V. Miller, J. W. Edwards, and P. B. Wood. 2003. Home-Range Size and Habitat Used by the Northern Myotis (*Myotis septentrionalis*). American Midland Naturalist 150(2): 352-359.

Patriquin, K. J. and R. M. R. Barclay. 2003. Foraging by Bats in Cleared, Thinned and Unharvested Boreal Forest. Journal of Applied Ecology 40: 646-657.

Pearson, E. W. 1962. Bats Hibernating in Silica Mines in Southern Illinois. Journal of Mammalogy 43(1): 27-33.

Pruitt. 2014. Technical Assistance Letter re: Headwaters Wind Farm LLC, Headwaters Wind Farm project, Randolph County, IN. Addressed to E. Johnston, EDP Renewables North America LLC, Chicago, IL. From S. Pruitt, Field Supervisor, US Fish and Wildlife Service Bloomington Field Office (Ecological Services), Bloomington, Indiana. Dated October 23, 2014. 2 pp.

Pruitt, L. and J. Okajima. 2014. Indiana Bat Fatalities at Wind Energy Facilities. US Fish and Wildlife Service (USFWS) Bloomington Indiana Field Office. Update December 2014. Available online at: http://www.fws.gov/midwest/wind/wildlifeimpacts/pdf/IndianaBatFatalitiesUpdatedDec2014.pdf

Racey, P. A. 1973. Environmental Factors Affecting Length of Gestation in Heterothermic Bats. Journal of Reproduction and Fertility 19(suppl.): 175-189.

Racey, P. A. 1979. The Prolonged Storage and Survival of Spermatozoa in Chiroptera. Journal of Reproduction and Fertility 56: 391-402.

Racey, P. A. 1982. Ecology of Bat Reproduction. Pp. 57-104. *In*: T. H. Kunz, ed. Ecology of Bats. Plenum Press, New York, New York. 425 pp.

Reeder, D. M., C. L. Frank, G. G. Turner, A. Kurta, E. R. Britzke, S. R. Darling, C. W. Stihler, A. C. Hicks, C. U. Meteyer, R. Jacob, L. A. Grieneisen, S. A. Brownlee, M. E. Vodzak, L. K. Muller, and D. S. Blehert. 2012. Frequent Arousal from Hibernation Linked to Severity of Infection and Mortality in Bats with White-Nose Syndrome. PLoS ONE 7(6): e38920. doi: 38910.31371/journal.pone.0038920.

Richter, A. R., S. R. Humphrey, J. B. Cope, and V. Brack. 1993. Modified Cave Entrances: Thermal Effect on Body Mass and Resulting Decline of Endangered Indiana Bats (*Myotis sodalis*). Conservation Biology 7: 407-415.

Ritzert, M., R. E. Good, and M. Sonnenberg. 2012. Post-Construction Monitoring at the Timber Road II Wind Energy Facility, Paulding County, Ohio. Draft Interim Report: August 1 – November 15, 2011. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 2012.

Rommé, R. C., A. B. Henry, R. A. King, T. Glueck, and K. Tyrell. 2002. Home Range near Hibernacula in Spring and Autumn. Pp. 153-158. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Rydell, J. 1991. Seasonal Use of Illuminated Areas by Foraging Northern Bats, *Eptesicus Nilssoni*. Holartic Ecology 14(3): 230-207.

Sanders, C. and J. Chenger. 2000. Allegheny Mountain Transportation Improvement Project: South Penn Tunnel *Myotis sodalis* Study. Prepared for Pennsylvania Turnpike Commission. Prepared by Bat Conservation and Management. 63 pp.

Sanders, C., J. Chenger, and B. Denlinger. 2001. Williams Lake Telemetry Study: New York Indiana Bat Spring Migration Tracking Study. Report for Bat Conservation and Management. 21 pp. http://www.batmanagement.com

Sasse, D. B. and P. J. Pekins. 1996. Summer Roosting Ecology of Northern Long-Eared Bats (*Myotis septentrionalis*) in the White Mountain National Forest. Pp. 91-101. *In*: R. M. R. Barclay and R. M. Brigham, eds. Bats and Forests Symposium. Ministry of Forests Research Program, Victoria, British Columbia, Canada.

Saugey, D. A., G. A. Heidt, D. R. Heath, and V. R. McDaniel. 1990. Hibernating Indiana Bats (*Myotis sodalis*) from the Ouachita Mountains of Southeastern Oklahoma. Southwestern Naturalist 35: 341-342.

Schmidt, C. A. 2001. Conservation Assessment for the Northern Myotis in the Black Hills National Forest, South Dakota and Wyoming. US Forest Service Report.

Schultes, K. L. and C. Elliott. 2002. Roost Tree Selection by Indiana Bats and Northern Bats on the Wayne National Forest, Ohio. Final Report for the US Fish and Wildlife Service (USFWS). February 11, 2002.

Sheets, J., J. O. Whitaker Jr., V. Brack Jr., and D. W. Sparks. 2013. Bats of the Hardwood Ecosystem Experiment before Timber Harvest: Assessment and Prognosis. General Technical Report NRS-P-108. US Department of Agriculture (USDA), Forest Service, Northern Research Station (NRS).

Shiel, C. B. and J. S. Fairley. 1998. Acitvity of Leisler's Bat *Nyctalus Leisleri* (Kuhl) in the Field in South-East County Wexford, as Revealed by a Bat Detector. Biology and Environment: Proceedings of the Royal Irish Academy 98B(2): 105-112.

Silvis, A., W. M. Ford, E. R. Britzke, N. R. Beane, and J. B. Johnson. 2012. Forest Succession and Maternity Day Roost Selection by *Myotis septentrionalis* in a Mesophytic Hardwood Forest. International Journal of Forestry Research 2012: doi: 10.1155/2012/148106.

Simon, S., R. E. Good, and M. Ritzert. 2014. Post-Construction Monitoring at the Timber Road II Wind Farm, Paulding County, Ohio. Final Report: April 1 - November 15, 2013. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc., Bloomington, Indiana. January 30, 2014.

Sparks, D. W., J.O. Whitaker, Jr., and C. M. Ritzi. 2004. Foraging Ecology of the Endangered Indiana Bat. Pp. 15-27. *In*: K. C. Vories and A. Harrington, eds. Indiana Bat and Coal Mining: A Technical Interactive Forum. US Department of Interior, Office of Surface Mining, Alton, Illinois Coal Research Center, Southern Illinois University, Carbondale, Illinois. Louisville, Kentucky.

Sparks, D. W., J. O. Whitaker, and C. M. Ritzi. 2005. Foraging Ecology of the Endangered Indiana Bat. Journal of Mammalogy 86: 713-718.

Stantec Consulting, Inc. (Stantec). 2011. Cohocton and Dutch Hill Wind Farms Year 2 Post-Construction Monitoring Report, 2010, for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC, and Canandaigua Power Partners II, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. October 2011.

Stantec Consulting, Inc. (Stantec). 2013. Final Buckeye Wind Power Project Habitat Conservation Plan. Prepared for Buckeye Wind LLC, Pittsburg, Pennsylvania. Prepared by Stantec, Topsham, Maine. March 2013. Available online at: https://www.fws.gov/midwest/endangered/permits/hcp/buckeyewind/pdf/finalhcpeis/BuckeyeFinalHCP25March2013.pdf

Stantec Consulting Ltd. (Stantec Ltd.). 2007. Kingsbridge I Wind Power Plant Post-Construction Bird and Bat Monitoring Report: 2006. File No. 160960204. Prepared by Stantec Ltd., Guelph, Ontario. March 7, 2007.

Stones, R. C. 1981. Endangered and Threatened Species Program: Survey of Winter Bat Populations in Search of the Indiana Bat in the Western Upper Peninsula of Michigan. Michigan Department of Natural Resources (MDNR).

Taucher, J., T. Librandi-Mumma, and W. Capouillez. 2012. Pennsylvania Game Commission Wind Energy Voluntary Cooperation Agreement Third Summary Report. Bureau of Wildlife Habitat Management, Pennsylvania Game Commission (PGC), Harrisburg, Pennsylvania. December 27, 2012. Available online at: http://www.batsandwind.org/pdf/PGC%203rd%20Wind%20Energy%20Summary%20Report%202012.pdf

Thogmartin, W. E., R. A. King, P. C. McKann, J. A. Szymanski, and L. Pruitt. 2012. Population-Level Impact of White-Nose Syndrome on the Endangered Indiana Bat. Journal of Mammalogy 93(4): 1086-1098.

Thogmartin, W. E., C. A.Sanders-Reed, J. A.Szymanski, P. C.McKann, L. Pruitt, R. A. King, M. C.Runge, and R. E.Russell. 2013. White-Nose Syndrome Is Likely to Extirpate the Endangered Indiana Bat over Large Parts of Its Range. Biological Conservation 160: 162–172.

Thomas, D. W., M. Dorais, and J. Bergeron. 1990. Winter Energy Budgets and Cost of Arousals for Hibernating Little Brown Bats, *Myotis lucifugus*. Journal of Mammalogy 71: 475-479.

Thompson, F.R. III., ed. 2006. Conservation Assessments for Five Forest Bat Species in the Eastern United States. General Technical Report Nc-260. North Central Research Station, US Department of Agriculture (USDA) Forest Service, St. Paul, Minnesota. pp. 82 pp.

Thomson, C. E. 1982. *Myotis sodalis*. Mammalian Species 163: 1-5.

Timpone, J. C., J. Boyles, K. Murray, D. P. Aubrey, and L. W. Robbins. 2010. Overlap in Roosting Habitats of Indiana Bat (*Myotis sodalis*) and Northern Bats (*Myotis septentrionalis*). American Midland Naturalist 163: 115-123.

Trombulak, S. C., P. E. Higuera, and M. DesMeules. 2001. Population Trends of Wintering Bats in Vermont. Northeastern Naturalist 8: 51-62.

Turner, G. 2006. Bat Migratory Behaviors and Routes in Pennsylvania and Maryland. Proceedings of the National Wind Coordinating Collaborative (NWCC) Wildlife Workgroup Research Planning Meeting VI, San Antonio, Texas. November 14-15, 2006.

Turner, G. G., D. M. Reeder, and J. T. H. Coleman. 2011. A Five-Year Assessment of Mortality and Geographic Spread of White-Nose Syndrome in North American Bats and a Look to the Future. Bat Research News 52: 13-27.

Tuttle, M. D. and D. M. Stevenson. 1978. Variation in the Cave Environment and Its Biological Implications. Pp. 108-121. *In*: National Cave Management Symposium Proceedings. Speleobooks, Adobe Press, Albuquerque, New Mexico.

Tuttle, M. D. and J. Kennedy. 2002. Thermal Requirements During Hibernation. Pp. 68-78. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

US Environmental Protection Agency (USEPA). 2017. Ecoregion Download Files by State - Region 5: Indiana. Ecoregions of the United States, Ecosystems Research, USEPA. Accessed February 2017. Information and maps available online at: https://www.epa.gov/eco-research/ecoregion-download-files-state-region-5#pane-12

US Fish and Wildlife Service (USFWS). 1967. The Endangered Species List - 1967. 32 Federal Register (FR) 48: 4001. March 11, 1967.

US Fish and Wildlife Service (USFWS). 1983. Recovery Plan for the Indiana Bat. USFWS, Washington, DC. 80 pp.

US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 1996. Habitat Conservation Planning and Incidental Take Permit Processing Handbook. November 4, 1996.

US Fish and Wildlife Service (USFWS). 1999. Agency Draft Indiana Bat (*Myotis sodalis*) Revised Recovery Plan. US Department of the Interior, Fish and Wildlife Service, Region 3. Fort Snelling, Minnesota.

US Fish and Wildlife Service (USFWS). 2004. Indiana Bat (*Myotis sodalis*). July 2004. USFWS, Northeast Region, Hadley, Massachusetts. 260 pp. http://www.fws.gov/northeast/pdf/indianabat.fs.pdf

US Fish and Wildlife Service (USFWS). 2007a. Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision. US Department of Interior, Fish and Wildlife Service, Region 3. USFWS. Fort Snelling, Minnesota. 260 pp. Available online at: http://ecos.fws.gov/docs/recovery_plan/070416.pdf

US Fish and Wildlife Service (USFWS). 2007b. Section 7(a)(2) Consultation Process: Indiana Bat - Summer Life History Information for Michigan. Midwest Region, USFWS. January 2007. Accessed October 12, 2016. Available online at: http://www.fws.gov/midwest/Endangered/section7/s7process/mammals/inba/inbaMIlifehist.html

US Fish and Wildlife Service (USFWS). 2008. Revised 2007 Rangewide Population Estimate for the Indiana Bat, *Myotis sodalis*. USFWS, Region 3. October 15, 2008.

US Fish and Wildlife Service (USFWS). 2009. Indiana Bat (*Myotis sodalis*) 5-Year Review: Summary and Evaluation. USFWS, Midwest Region, Region 3, Bloomington Ecological Field Office, Bloomington, Indiana. September 2009.

US Fish and Wildlife Service (USFWS). 2011a. Indiana Bat Section 7 and Section 10 Guidance for Wind Energy Projects. Revised October 26, 2011. Available online at: http://www.fws.gov/midwest/endangered/mammals/inba/pdf/inbaS7and10WindGuidanceFinal26Oct2011.pdf

US Fish and Wildlife Service (USFWS). 2011b. A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats. May 2011. Available online at: http://whitenosesyndrome.org/sites/default/files/white-nose_syndrome_national_plan_may_2011.pdf

US Fish and Wildlife Service (USFWS). 2011c. U.S. Fish and Wildlife Service Statement on Indiana Bat Fatality at North Allegheny Wind Facility. Lowell Whitney, Northeast Regional HCP Coordinator, USFWS.

US Fish and Wildlife Service (USFWS). 2012a. Endangered Indiana Bat Found Dead at Ohio Wind Facility; Steps Underway to Reduce Future Mortalities. Newsroom, Midwest Region, USFWS. November 29, 2012. Available online at: http://www.fws.gov/midwest/news/604.html

US Fish and Wildlife Service (USFWS). 2012b. Indiana Bat Fatality at West Virginia Wind Facility. West Virginia Field Office, Northeast Region, USFWS. Last updated August 23, 2012. Available online at: http://www.fws.gov/westvirginiafieldoffice/ibatfatality.html

US Fish and Wildlife Service (USFWS). 2012c. Land-Based Wind Energy Guidelines. March 23, 2012. 82 pp. Available online at: http://www.fws.gov/cno/pdf/Energy/2012_Wind_Energy_Guidelines_final.pdf

US Fish and Wildlife Service (USFWS). 2012d. North American Bat Death Toll Exceeds 5.5 Million from White-Nose Syndrome. USFWS News Release, USFWS Office of Communications, Arlington, Virginia. January 17, 2012. Available online at: http://whitenosesyndrome.org/sites/default/files/files/wns_mortality_2012_nr_final.pdf

US Fish and Wildlife Service (USFWS). 2013a. 2013 Rangewide Population Estimate for the Indiana Bat (*Myotis sodalis*) by USFWS Region. USFWS Endangered Species Program: Midwest Region. Compiled by A. King, Ecological Services Field Office, USFWS, Bloomington, Indiana. Revised August 26, 2013. Available online at: http://pbadupws.nrc.gov/docs/ML1428/ML14286A006.pdf

US Fish and Wildlife Service (USFWS). 2013b. 2013 Revised Range-Wide Indiana Bat Summer Survey Guidelines. May 2013. Available online at: http://www.fws.gov/arkansas-es/docs/FinalRevised2013IndianaBatSummerSurveyGuidelines5May2013.pdf

US Fish and Wildlife Service (USFWS). 2013c. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List the Eastern Small-Footed Bat and the Northern Long-Eared Bat as Endangered or Threatened Species; Listing the Northern Long-Eared Bat as an Endangered Species. Docket No. FWS-R5-ES-2011-0024. 78 Federal Register (FR) 191: 61046-61080. October 2, 2013.

US Fish and Wildlife Service (USFWS). 2013d. Fowler Ridge Wind Farm, Benton County, Indiana: Indiana Bat Habitat Conservation Plan Prepared by Fowler Ridge Wind Farm LLC, Fowler Ridge II Wind Farm LLC, Fowler Ridge III Wind Farm LLC, and Fowler Ridge IV W ind Farm LLC, in consultation with Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Bloomington, Indiana. November 2013. Available online at: http://www.fws.gov/midwest/endangered/permits/hcp/FowlerRidge/pdf/FowlerRidgeWindFarmFinalHCP120913.pdf

US Fish and Wildlife Service (USFWS). 2014a. 2014 Revised Range-Wide Indiana Bat Summer Survey Guidelines. January 2014. Available online at: http://www.fws.gov/athens/pdf/2014IBatSummerSurveyGuidelines13Jan2014.pdf

US Fish and Wildlife Service (USFWS). 2014b. Northern Long-Eared Bat Interim Conference and Planning Guidance. USFWS Regions 2, 3, 4, 5, and 6. January 6, 2014. Available online at: http://www.fws.gov/northeast/virginiafield/pdf/NLEBinterimGuidance6Jan2014.pdf

US Fish and Wildlife Service (USFWS). 2014c. White-Nose Syndrome: The Devastating Disease of Hibernating Bats in North America. August 2014. Available online at: https://www.whitenosesyndrome.org/sites/default/files/resource/white-nose_fact_sheet_8-2014_0.pdf

US Fish and Wildlife Service (USFWS). 2015b. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat with 4(d) Rule; Final Rule and Interim Rule. Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17. 80 Federal Register (FR) 63: 17974-18033. April 2, 2015.

US Fish and Wildlife Service (USFWS). 2015c. White-Nose Syndrome: The Devastating Disease of Hibernating Bats in North America. July 2015. Available online at: https://www.fws.gov/mountain-prairie/pressrel/2015/WNS%20Fact%20Sheet%20Updated%2007012015.pdf

US Fish and Wildlife Service (USFWS). 2016a. 2016 Rangewide Indiana Bat Summer Survey Guidelines. Updated April 11, 2016. Available online at: http://www.fws.gov/midwest/endangered/mammals/inba/surveys/pdf/2016IndianaBatSummerSurveyGuidelines11April2016.pdf

US Fish and Wildlife Service (USFWS). 2016b. Endangered and Threatened Wildlife and Plants; 4(d) Rule for the Northern Long-Eared Bat; Final Rule. 50 CFR Part 17. Department of the Interior Fish and Wildlife Service. 81 Federal Register (FR) 9: 1900-1922. January 14, 2016.

US Fish and Wildlife Service (USFWS). 2016c. Endangered and Threatened Wildlife and Plants; Determination That Designation of Critical Habitat Is Not Prudent for the Northern Long-Eared Bat; Critical Habitat Determination. 50 CFR Part 17. Department of the Interior Fish and Wildlife Service. 81 Federal Register (FR) 81: 24707-24714. April 27, 2016.

US Fish and Wildlife Service (USFWS). 2016d. Midwest Wind Energy Multi-Species Habitat Conservation Plan. Public Review Draft. US Fish and Wildlife Service Midwest Region in collaboration with the States of Iowa, Illinois, Indiana, Michigan, Minnesota, Missouri, and Wisconsin and the American Wind Energy Association (AWEA). April 2016.

US Fish and Wildlife Service (USFWS). 2016e. Programmatic Biological Opinion on Final 4(d) Rule for Northern Long-Eared Bat and Activities Excepted from Take Prohibitions. USFWS Regions 2, 3, 4, 5, and 6. Prepared by USFWS, Midwest Regional Office, Bloomington, Minnesota. January 5, 2016. Available online at: https://www.fws.gov/Midwest/endangered/mammals/nleb/pdf/BOnlebFinal4d.pdf

US Fish and Wildlife Service (USFWS). 2016f. US Counties within Indiana in Which the Northern Long-Eared Bat, Wherever Found Is Known to or Is Believed to Occur. USFWS Environmental Conservation Online System (ECOS). Updated October 2016. ECOS available at: http://ecos.fws.gov/ecos/indexPublic.do; Northern long-eared bat species profile available online at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A0JE; Occurance information in Indiana available online at: https://ecos.fws.gov/ecp0/profile/countiesByState?entityId=10043&state=Indiana

US Fish and Wildlife Service (USFWS). 2016g. Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects. Bloomington Field Office, Bloomington, Indiana.

US Fish and Wildlife Service (USFWS). 2016h. Region 3 Northern Long-Eared Bat Resource Equivalency Analysis Model for Wind Energy Projects. Bloomington Field Office, Bloomington, Indiana.

US Fish and Wildlife Service (USFWS). 2017. 2017 Rangewide Population Estimate for the Indiana Bat (*Myotis sodalis*) by USFWS Region. USFWS Endangered Species Program: Midwest Region. Compiled by A. King, Ecological Services Field Office, USFWS, Bloomington, Indiana, from data gathered from bat biologists throughout the species' range. Revised July 5, 2017. Available online at: https://www.fws.gov/midwest/endangered/mammals/inba/pdf/2017IBatPopEstimate5July2017.pdf

US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 2016. Habitat Conservation Planning and Incidental Take Permit Processing Handbook. December 21, 2016. Available online at: https://www.fws.gov/endangered/esa-library/pdf/HCP_Handbook.pdf

US Geological Survey (USGS). 2009. Investigating White Nose Syndrome in Bats: Fact Sheet 2009-3058. July 2009. Available online at: http://pubs.usgs.gov/fs/2009/3058/pdf/fs2009-3058.pdf

US Geological Survey (USGS) National Land Cover Database (NLCD). 2011. National Land Cover Database 2011 (NLCD 2011). Multi-Resolution Land Characteristics Consortium (MRLC), National Land Cover Database (NLCD). USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota. Information available online at: http://www.mrlc.gov/nlcd2011.php; Legend information available at: http://www.mrlc.gov/nlcd11_leg.php

Vaughan, N., G. Jones, and S. Harris. 1997. Habitat Use by Bats (Chiroptera) Assessed by Means of a Broad-Band Acoustic Method. Journal of Applied Ecology 34(3): 716-730.

Verant, M. L., C. U. Meteyer, J. R. Speakman, P. M. Cryan, J. M. Lorch, and D. S. Blehert. 2014. White-Nose Syndrome Initiates a Cascade of Physiologic Disturbances in the Hibernating Bat Host. BioMed Central (BMC) Physiology 14: 10.

Vonhof, M. J. and R. M. R. Barclay. 1996. Roost-Site Selection and Roosting Ecology of Forest-Dwelling Bats in Southern British Columbia. Canadian Journal of Zoology 74: 1797-1805.

Watrous, K. S., T. M. Donovan, R. M. Mickey, S. R. Darling, A. C. Hicks, and S.L. von Oettingen. 2006. Predicting Minimum Habitat Characteristics for the Indiana Bat in the Champlain Valley. Journal of Wildlife Management 70: 1228-1237.

Whitaker, J. O., Jr. and V. Brack. 2002. Distribution and Summer Ecology in Indiana. Pp. 48-54. *In*: A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International (BCI), Austin, Texas.

Whitaker, J. O. Jr. and W. J. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, New York. 583 pp.

Whitaker, J. O. and R. E. Mumford, eds. 2009. *Myotis septentrionalis* / Northern Myotis. *In:* Mammals of Indiana. Indiana University Press.

Whitaker, J. O. Jr. and L. J. Rissler. 1992. Winter Activity of Bats at a Mine Entrance in Vermillion County, Indiana. American Midland Naturalist 127: 52-59.

Whitaker, J. O. and F. A. Winter. 1977. Bats of the Caves and Mines of the Shawnee National Forest, Southern Illinois. Transactions of the Illinois Academy of Science 70: 301-313.

Whitaker, J.O. Jr., V. Brack, and J. B. Cope. 2002. Are Bats in Indiana Declining? Proceedings of the Indiana Academy of Science 1: 95-106.

White-Nose Syndrome.org. 2017. Where Is It Now? WNS Info, White-Nose Syndrome.org. March 15, 2017. Information available online at: https://www.whitenosesyndrome.org/about/where-is-it-now; Spread maps available online at: https://www.whitenosesyndrome.org/resources/map

Wilde, C. J., C. H. Knight, and P. A. Racey. 1999. Influence of Torpor on Milk Protein Composition and Secretion in Lactating Bats. Journal of Experimental Biology 284: 35-41.

Winhold, L., E. Hough, and A. Kurta. 2005. Long-Term Fidelity of Tree-Roosting Bats to a Home Area. Bat Research News 46: 9-10.

Winhold, L. and A. Kurta. 2006. Aspects of Migration by the Endangered Indiana Bat, *Myotis sodalis*. Bat Research News 46: 9-10.

Woodward, S. L. and R. L. Hoffman. 1991. The Nature of Virginia. *In:* Virginia's Endangered Species: Proceedings of a Symposium. Pp. 23-48. K. Terwilliger (coordinator). McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Yates, M. and R. M. Muzika. 2006. Effect of Forest Structure and Fragmentation on Site Occupancy of Bat Species in Missouri Ozark Forests. Journal of Wildlife Management 70: 1238-1248.

Young, D.P., Jr., W. P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring, July - October 2008. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. February 17, 2009.

Young, D.P., Jr., C. Nations, M. Lout, and K. Bay. 2013. 2012 Post-Construction Monitoring Study, Criterion Wind Project, Garrett County, Maryland. April - November 2012. Prepared for Criterion Power Partners, LLC, Oakland, Maryland. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Waterbury, Vermont. January 15, 2013.

9.2 Laws, Acts, and Regulations Cited

16 United States Code (USC) 1531. 1973. Title 16 - Conservation; Chapter 35 - Endangered Species; Section (§) 1531 - Congressional Findings and Declaration of Purposes and Policy. 16 USC 1531. (Public Law [Pub. L.] 93–205, § 2, December 28, 1973, 87 Statute [Stat.] 884; Pub. L. 96-159, § 1, December 28, 1979, 93 Stat. 1225; Pub. L. 97–304, § 9(a), October 13, 1982, 96 Stat. 1426; Pub. L. 100–478, title I, § 1013(a), October 7, 1988, 102 Stat. 2315). Available online at: https://www.gpo.gov/fdsys/pkg/USCODE-2012-title16/html/USCODE-2012-title16-chap35-sec1531.htm

16 United States Code (USC) 1532. 1973. Title 16 - Conservation; Chapter 35 - Endangered Species; Section (§) 1532 - Definitions. 16 USC 1532. (Public Law [Pub. L.] 93–205, § 3, December 28, 1973, 87 Statute [Stat.] 885; Pub. L. 94–359, § 5, July 12, 1976, 90 Stat. 913; Pub. L. 95–632, § 2, November 10, 1978, 92 Stat. 3751; Pub. L. 96–159, § 2, December 28, 1979, 93 Stat. 1225; Pub. L. 97–304, § 4(b), October 13, 1982, 96 Stat. 1420; Pub. L. 100–478, Title I, § 1001, October 7, 1988, 102 Stat. 2306). Available online at: https://www.gpo.gov/fdsys/pkg/USCODE-2011-title16/pdf/USCODE-2011-title16-chap35-sec1532.pdf

16 United States Code (USC) 1536. 1973. Title 16 - Conservation; Chapter 35 - Endangered Species; Section (§) 1536 - Interagency Cooperation. 16 USC 1536. (Public Law [Pub. L.] 93–205, § 7, December 28, 1973, 87 Statute [Stat.] 892; Pub. L. 95–632, § 3, November 10, 1978, 92 Stat. 3752; Pub. L. 96–159, § 4, December 28, 1979, 93 Stat. 1226; Pub. L. 97–304, §§ 4(a), 8(b), October 13, 1982, 96 Stat. 1417, 1426; Pub. L. 99–659, Title IV, § 411(b), (c), November 14, 1986, 100 Stat. 3741, 3742; Pub. L. 100–707, Title I, § 109(g), November 23, 1988, 102 Stat. 4709). Available online at: https://www.gpo.gov/fdsys/pkg/USCODE-2011-title16/pdf/USCODE-2011-title16-chap35-sec1536.pdf

16 United States Code (USC) 1538. 1973. Title 16 - Conservation; Chapter 35 - Endangered Species; Section (§) 1538 - Prohibited Acts. 16 USC 1538. (Public Law [Pub. L.] 93–205, § 9, December 28, 1973, 87 Statute [Stat.] 893; Pub. L. 95–632, § 4, November 10, 1978, 92 Stat. 3760; Pub. L. 97–304, § 9(b), October 13, 1982, 96 Stat. 1426; Pub. L. 100–478, Title I, § 1006, Title II, § 2301, October 7, 1988, 102 Stat. 2308, 2321; Pub. L. 100–653, Title IX, § 905, November 14, 1988, 102 Stat. 3835). Available online at: https://www.gpo.gov/fdsys/pkg/USCODE-2011-title16/pdf/USCODE-2011-title16-chap35-sec1538.pdf

16 United States Code (USC) 1539. 1973. Title 16 - Conservation; Chapter 35 - Endangered Species; Section (§) 1539 - Exceptions. 16 USC 1539. (Public Law [Pub. L.] 93–205, § 10, December 28, 1973, 87 Statute [Stat.] 896; Pub. L. 94–359, §§ 2, 3, July 12, 1976, 90 Stat. 911, 912; Pub. L. 95–632, § 5, November 10, 1978, 92 Stat. 3760; Pub. L. 96–159, § 7, December 28, 1979, 93 Stat. 1230; Pub. L. 97–304, § 6(1)–(4)(A), (5), (6), October 13, 1982, 96 Stat. 1422–1424; Pub. L. 100–478, Title I, §§ 1011, 1013 (b), (c), October 7, 1988, 102 Stat. 2314, 2315). Available online at: https://www.gpo.gov/fdsys/pkg/USCODE-2011-title16/pdf/USCODE-2011-title16-chap35-sec1539.pdf

16 United States Code (USC) §§ 1531-1599. 1973. Title 16 - Conservation; Chapter 35 - Endangered Species; Sections (§§) 1531-1599. Endanged Species Act. 16 USC 1531-1599. P.L. 93-205, 84 Stat. 884 (codified as amended).

42 United States Code (USC) §§ 4321-4370h. 1970. Title 42 - the Public Health and Welfare; Chapter 55 - National Environmental Policy; Subchapters I (Policies and Goals) and II (Council on Environmental Quality); Sections (§§) 4321-4370h; National Environmental Policy Act. 42 USC 4321-4370h. [Pub. L. 91–190, § 2, Jan. 1, 1970, 83 Stat. 852.].

50 Code of Federal Regulations (CFR) 13.22. 1989. Title 50 - Wildlife and Fisheries; Chapter I - United States Fish and Wildlife Service, Department of the Interior; Subchapter B - Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 13 - General Permit Procedures; Subpart C - Permit Administration; § 13.22 - Renewal of Permits. 50 CFR 13.22. 54 FR 38148, Sept. 14, 1989, as amended at 72 FR 48446, Aug. 23, 2007.

50 Code of Federal Regulations (CFR) 13.23. 1989. Title 50 - Wildlife and Fisheries; Chapter I - United States Fish and Wildlife Service, Department of the Interior; Subchapter B - Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 13 - General Permit Procedures; Subpart C - Permit Administration; § 13.23 - Amendment of Permits. 50 CFR 13.23. 54 FR 38148, Sept. 14, 1989, as amended at 64 FR 32711, June 17, 1999.

50 Code of Federal Regulations (CFR) 17.3. 1978. Title 50 - Wildlife and Fisheries; Chapter I - United States Fish and Wildlife Service, Department of the Interior; Subchapter B - Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 17 - Endangered and Threatened Wildlife and Plants; Subpart a - Introduction and General Provisions; Section (§)17.3. Definitions. [40 FR 44415, Sept. 26, 1975, as amended at 42 FR 28056, June 1, 1977; 44 FR 54006, Sept. 17, 1979; 46 FR 54750, Nov. 4, 1981; 47 FR 31387, July 20, 1982; 50 FR 39687, Sept. 30, 1985; 63 FR 8870, Feb. 23, 1998; 63 FR 48639, Sept. 11, 1998; 69 FR 24092, May 3, 2004; 71 FR 46870, Aug. 15, 2006].

50 Code of Federal Regulations (CFR) 17.22. 1985. Title 50 - Wildlife and Fisheries; Chapter I -United States Fish and Wildlife Service, Department of the Interior; Subchapter B - Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 17 -Endangered and Threatened Wildlife and Plants; Subpart C - Endangered Wildlife; Section (§) 17.22 - Permits for Scientific Purposes, Enhancement of Propagation or Survival, or for Incidental Taking. 50 CFR 17.22. [50 Federal Register (FR) 39687, September 30, 1985, as amended at 63 FR 8871, February 23, 1998; 63 FR 52635, October 1, 1998; 64 FR 32711, June 17, 1999; 64 FR 52676, September 30, 1999; 69 FR 24092, May 3, 2004; 69 FR 29670, May 25, 2004; 69 FR 71731, December 10, 2004].

50 Code of Federal Regulations (CFR) 17.31. 1978. Title 50 - Wildlife and Fisheries; Chapter I - United States Fish and Wildlife Service, Department of the Interior; Subchapter B - Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 17 - Endangered and Threatened Wildlife and Plants; Subpart D - Threatened Wildlife; Section (§) 17.31. Prohibitions. 50 CFR 17.31. [43 Federal Register (FR) 18181, April 28, 1978, as amended at 44 FR 31580, May 31, 1979; 70 FR 10503, March 4, 2005].

50 Code of Federal Regulations (CFR) 17.32. 1985. Title 50 - Wildlife and Fisheries; Chapter I -United States Fish and Wildlife Service, Department of the Interior; Subchapter B - Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 17 - Endangered and Threatened Wildlife and Plants; Subpart D - Threatened Wildlife; Section (§) 17.32 - Permits-General. 50 CFR 17.32. [50 Federal Register (FR) 39689, September 30, 1985, as amended at 63 FR 8871, February 23, 1998; 63 FR 52635, October 1, 1998; 64 FR 32714, June 17, 1999; 64 FR 52676, September 30, 1999; 69 FR 24093, May 3, 2004; 69 FR 29670, May 25, 2004; 69 FR 71731, December 10, 2004].

50 Code of Federal Regulations (CFR) 222.305. Title 50 - Wildlife and Fisheries; Chapter II - National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce; Subchapter C - Marine Mammals; Part 222 - General Endangered and Threatened Marine Species; Subpart C - General Permit Procedures; § 222.305 - Rights of Succession and Transfer of Permits. 50 CFR 222.305. [64 FR 14054, March 23, 1999, as amended at 67 FR 57973, September 13, 2002]. Available online at: https://www.gpo.gov/fdsys/pkg/CFR-2011-title50-vol9/xml/CFR-2011-title50-vol9-sec222-305.xml

50 Code of Federal Regulations (CFR) 402.02. 1986. Title 50 - Wildlife and Fisheries; Chapter IV- Joint Regulations (United States Fish and Wildlife Service, Department of the Interior and National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce); Endangered Species Committee Regulations; Subchapter a; Part 402 - Interagency Cooperation-Endangered Species Act of 1973, as Amended; Subpart a - General; Section (§) 402.02 - Definitions. 50 CFR 402.02; 51 Federal Register (FR) 19957, June 3, 1986, as amended 73 FR 76286, December 16, 2008, 74 FR 20422, May 4, 2009.

50 Code of Federal Regulations (CFR) § 13.25. 1999. Title 50 - Wildlife and Fisheries; Chapter I - United States Fish and Wildlife Service, Department of the Interior; Subchapter B Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants; Part 13 - General Permit Proceedures; Subpart C - Permit Administration; Section (§) 13.25 - Transfer of Permits and Scope of Permit Authorization. 50 CFR 13.25. [64 Federal Register (FR) 32711, June 17, 1999, as amended at 64 FR 52676, September 30, 1999; 69 FR 24092, May 3, 2004; 78 FR 73725, December 9, 2013].

63 Federal Register (FR) 35: 8859-8873. 1998. Habitat Conservation Plan Assurances (''No Surprises'') Rule. Final Rule. 50 CFR 17. Department of the Interior Fish and W ildlife Service. 50 CFR 222. Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service. 63 FR 8859. February 23, 1998. Available online at: https://www.fws.gov/Endangered/esa-library/pdf/f980223.pdf

80 Federal Register (FR) 63: 17974-18033. 2015. 50 CFR 17. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat with 4(d) Rule. Final rule, and interim rule with request for comments. Department of the Interior Fish and Wildlife Service. 80 FR 17974. April 2, 2015. Available online at: http://www.fws.gov/midwest/endangered/mammals/nleb/pdf/FRnlebFinalListing02April2015.pdf

81 Federal Register (FR) 9: 1900-1922. 2016. 50 CFR 17. Endangered and Threatened Wildlife and Plants; 4(d) Rule for the Northern Long-Eared Bat. Final Rule. Department of the Interior Fish and Wildlife Service. 81 FR 1900. January 14, 2016. Available online at: http://www.fws.gov/Midwest/endangered/mammals/nleb/pdf/FRnlebFinal4dRule14Jan2016.pdf

Endangered Species Act (ESA). 1973. 16 United States Code (USC) §§ 1531-1544, Public Law (PL) 93-205, December 28, 1973, as amended, PL 100-478 [16 USC 1531 *et seq.*]; 50 Code of Federal Regulations (CFR) 402.

Endangered Species Act (ESA) § 2. 1973. Section 2 - Findings, Purposes, and Policy. [As amended by Public Law (P.L.) 94-325, June 30, 1976; P.L. 94-359, July 12, 1976; P.L. 95-212, December 19, 1977; P.L. 95-632, November 10, 1978; P.L. 96-159, December 28, 1979; P.L. 97-304, October 13, 1982; P.L. 98-327, June 25, 1984; and P.L. 100-478, October 7, 1988; P.L. 107-171, May 13, 2002; P.L. 108-136, November 24, 2003].

Endangered Species Act (ESA) § 3. 1973. Section 3 - Definitions. [As amended by P.L. 94-325, June 30, 1976; P.L. 94-359, July 12, 1976; P.L. 95-212, December 19, 1977; P.L. 95-632, November 10, 1978; P.L. 96-159, December 28, 1979; P.L. 97-304, October 13, 1982; P.L. 98-327, June 25, 1984; and P.L. 100-478, October 7, 1988; P.L. 107-171, May 13, 2002; P.L. 108-136, November 24, 2003.].

Endangered Species Act (ESA) § 7. 1973. Section 7 - Interagency Cooperation. [As amended by P.L. 94-325, June 30, 1976; P.L. 94-359, July 12, 1976; P.L. 95-212, December 19, 1977; P.L. 95-632, November 10, 1978; P.L. 96-159, December 28, 1979; P.L. 97-304, October 13, 1982; P.L. 98-327, June 25, 1984; and P.L. 100-478, October 7, 1988; P.L. 107-171, May 13, 2002; P.L. 108-136, November 24, 2003.].

Endangered Species Act (ESA) § 9. 1973. Section 9 - Prohibited Acts. [As amended by P.L. 94-325, June 30, 1976; P.L. 94-359, July 12, 1976; P.L. 95-212, December 19, 1977; P.L. 95-632, November 10, 1978; P.L. 96-159, December 28, 1979; P.L. 97-304, October 13, 1982; P.L. 98-327, June 25, 1984; and P.L. 100-478, October 7, 1988; P.L. 107-171, May 13, 2002; P.L. 108-136, November 24, 2003.].

Endangered Species Act (ESA) § 10. 1973. Section 10 - Exceptions. [As amended by P.L. 94-325, June 30, 1976; P.L. 94-359, July 12, 1976; P.L. 95-212, December 19, 1977; P.L. 95-632, November 10, 1978; P.L. 96-159, December 28, 1979; P.L. 97-304, October 13, 1982; P.L. 98-327, June 25, 1984; and P.L. 100-478, October 7, 1988; P.L. 107-171, May 13, 2002; P.L. 108-136, November 24, 2003.].

Endangered Species Preservation Act (ESPA). 1966. Public Law (PL) 89-669, Statute 926. October 15, 1966.

National Environmental Policy Act (NEPA). 1970. 42 United States Code (USC) 4321-4370h. Public Law 91-190, § 2, January 1, 1970, 83 Statute 852.

National Historic Preservation Act (NHPA). 1966. 16 United States Code §§ 470 Et Seq. October 15, 1966.

9.3 Personal Communications

Armstrong, Mike. USFWS.

Butchkoski, Cal. 2010. Pennsylvania Game Commission (PGC).

Chenger, John. 2011. Bat Conservation Management (BCM).

Dalthorp, Daniel. 2016. Forest and Rangeland Ecosystem Science Center, US Geological Survey (USGS).

Darling, Scott. 2010. Vermont Department of Fish and Wildlife.

Herzog, Carl. 2011. New York State Department of Environmental Conservation (NYSDEC).

King, Andrew. 2005. US Fish and Wildlife Service (USFWS).

Lott, Keith. USFWS.

Pruitt, Lori. 2011. USFWS.

Reed, Mary. USFWS.

Reynolds, Rick. 2010. Virginia Department of Game and Inland Fisheries (VDGIF).

Robbins, Lynn. 2010. Missouri State University.

Seymour, Megan. 2015. USFWS.

Stihler, Craig. West Virginia Department of Natural Resources (WVDNR).

Taucher, John. PGC.

Turner, Greg. 2011. PGC.

9.4 Acronyms and Abbreviations

§	Section
°	degree
2007 Draft Indiana Bat Recovery Plan	*Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision*
2017 Range-Wide Population Estimate	*2017 Rangewide Population Estimate for the Indiana Bat (Myotis sodalis) by USFWS Region*
ac	acre
Applicant	Headwaters Wind Farm LLC
ASL	above sea level
BO	Biological Opinion
C	Celsius
CFR	Code of Federal Regulations
CI	confidence interval
cm	centimeter
CO^2	carbon dioxide
Covered Activities	The operation of the Project and mitigation measures prescribed in this HCP
Covered Species	Indiana bat and northern long-eared bat
dbh	diameter-at-breast-height
DNA	deoxyribonucleic acid
EDPR	EDP Renewables North America LLC
EoA	Evidence of Absence
ESA	Endangered Species Act
F	Fahrenheit
FAA	Federal Aviation Administration
FFO	Frankfort Field Office
FR	Federal Register
FRWF	Fowler Ridge Wind Farm
ft	foot
ft/s	feet per second
ft^2	square foot
g	gram
g value	probability of detection
ha	hectare
HCP	Habitat Conservation Plan
HCP Handbook	Revised 2016 *Habitat Conservation Planning and Incidental Take Permit Processing Handbook*

IDNR	Indiana Department of Natural Resources
Indiana Bat REA Model	*Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects, Version 7*
INFO	Indiana Field Office
ITP	Incidental Take Permit
k	the factor by which searcher efficiency changes as undetected carcasses age
KDWR	Kentucky Department of Fish and Wildlife Resources
KFO	Kentucky Field Office
km	kilometer
listed species	The species listed as threatened or endangered under the ESA
m	meter
M	the projected cumulative take amount in the EoA model
m/s	meters per second
m^2	square meter
met	meteorological
mi	mile
MRU	Midwest Recovery Unit
MW	megawatt
N	north
NAD	North American Datum
NatGeo	National Geographic
NEPA	National Environmental Policy Act
NLCD	National Land Cover Database
NMFS	National Marine Fisheries Service
Northern Long-Eared Bat Interim Guidance	*Northern Long-Eared Bat Interim Guidance and Planning Guide*
Northern Long-Eared Bat REA Model	*Region 3 Northern Long-Eared Bat Resource Equivalency Analysis Model for Wind Energy Projects, Version 1*
NYSDEC	New York State Department of Environmental Conservation
O&M	operations and maintenance
oz	ounce
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
Pd	*Pseudogymnoascus destructans*
Permit	Incidental Take Permit
Permit Area	The area in which all 100 turbines will be located, and all easements, fee lands, and land leased for other facilities associated with the Project
Plan Area	The geographic area that is analyzed in the NEPA analysis and the ESA §7 intra-Service consultation
Project	Headwaters Wind Farm
REA	Resource Equivalency Model
right-of-way	ROW
SCADA	supervisory control and data acquisition
Service	United States Fish and Wildlife Service
TRII	Timber Road II Wind Energy Facility

US	United States
USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	US Geological Survey
UTM	Universal Transverse Mercator
UTM	Universal Transverse Mercator
VDGIF	Virginia Department of Game and Inland Fisheries
vs.	versus
WNS	white-nose syndrome
WVDNR	West Virginia Department of Natural Resources
λ	rolling 3-year take rate in the EoA model

Appendix A. Mitigation Credit for the Headwaters Wind Farm Habitat Conservation Plan

NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS
408 W. 6th Street, Bloomington, IN 47404
Phone: 812-339-1756 ◆ www.west-inc.com

TECHNICAL MEMORANDUM

Date: November 15, 2016, revised July 24, 2017 and March 12, 2018

To: Scott Pruitt, Marissa Reed, U.S. Fish and Wildlife Service, Bloomington Field Office

From: Quintana Hayden, Cara Meinke, and Rhett Good, Western EcoSystems Technology, Inc. and Erin O'Shea and Christina Calabrese, EDP Renewables, North America

Subject: Revised Proposed Impact of Take Estimates and Mitigation Credit Calculations for the Headwaters Wind Farm Habitat Conservation Plan

BACKGROUND

The memo that follows describes the proposed impact of take estimates for the Covered Species (Indiana bat [*Myotis sodalis*] and northern long-eared bat [*Myotis septentrionalis*]) of the Headwaters Habitat Conservation Plan (HCP). The proposed mitigation credit calculation for the mitigation project for the Headwaters HCP is then described. The mitigation project is winter habitat protection: gating of Wind Cave in Kentucky.

IMPACT OF TAKE ESTIMATES

Indiana Bat

The Applicant estimates that a total of 9.55 Indiana bats will be taken each year during the 27-year ITP term. Approximately 75% of the incidental take is expected to be attributed to females, which would result in an annual female take of 7.16. Using the U.S. Fish and Wildlife Service's (USFWS') Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects, Public Version 1 (USFWS 2016a) and a declining population, the total estimated lost reproductive capacity resulting from the Project is 308 Indiana bats, resulting in a total estimated impact of 501 Indiana bats over the life of the Project. This impact of take averages approximately 18.55 Indiana bats per year over the 27-year ITP term.

Northern Long-eared Bat

The Applicant estimates that a total of 2.53 northern long-eared bats will be taken each year during the 27-year ITP term. Approximately 50% of the incidental take is expected to be attributed to females, which would result in an annual female take of 1.26. Using the USFWS' Region 3 Northern Long-eared Bat Resource Equivalency Analysis Model for Wind Energy Projects, Public Version 1 (USFWS 2016b) and a declining population, the total estimated lost reproductive capacity resulting from the Project is 54 northern long-eared bats, resulting in a total estimated impact of 88 northern long-eared bats over the life of the Project. This impact of take averages approximately 3.26 northern long-eared bats per year over the 27-year ITP term.

WIND CAVE GATING PROJECT

Wind Cave is a Priority 2 Indiana bat hibernaculum. In 2015, the cave was home to 2,878 Indiana bats (down from 3,537 observed in 2013). As many as 60 northern long-eared bats were also observed in the cave in 2013; however, subsequent acoustic monitoring conducted in 2015 revealed that northern long-eared bats are no longer present in the cave in any appreciable numbers. Other bat species known to use the cave include the little brown bat, tri-colored bat, eastern small-footed bat (*M. leibii*), big brown bat (*Eptesicus fuscus*), and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*).

In terms of potential for human disturbance, the cave location is well-known to the public and the entrance is located near a road. The landowner who owns the cave has noted use of the cave by trespassers. It is highly likely that this use creates disturbance for hibernating Indiana bats since greater than 75% of the hibernating population of Indiana bats in the cave is clustered in low ceiling areas that are vulnerable to disturbance and/or predation. Therefore, the cave gating project will minimize the potential for Indiana and northern long-eared bats, if they return to the cave, to be negatively affected by potential vandalism in the future, providing an important conservation benefit for both species.

Indiana bats are known to migrate from hibernacula in Kentucky to summer habitat as far north as Michigan (Kurta 2004); therefore, it is likely that protection of winter habitat in Kentucky will benefit Indiana bats that establish maternity colonies in Indiana, or that migrate through Indiana. Due to the fact that Indiana bat populations are currently being decimated by WNS, protection of hibernacula from additional sources of stress is of the utmost importance. Wind Cave is considered by the USFWS Frankfort Field Office (USFWS FFO) and KDFWR to be the highest priority cave left to be gated in Kentucky.

The first cave gating phase consisted of pre-installation monitoring conducted in 2015. Direct impacts to bats could occur if bats collide with gate slats or have to expend extra energy to navigate around the gate structures. Due to this potential risk, a qualified bat biologist monitored the cave entrance with two thermal infrared cameras to identify bat flight paths and determined that the planned position of the gate in the cave is unlikely to impede the flight paths of bats or cause them to expend extra energy. Harp trapping conducted April 14, 2015 yielded three Indiana bats, one little brown bat, one eastern small-footed bat, and one tricolored bat. Dataloggers were also installed in fall 2015 to document temperature, humidity, and human usage of the cave prior to gating.

The second cave gating phase will consist of gate design and construction. The cave gate will be modeled after designs of other successful bat gates that have resulted in increased populations of Indiana bats (bat-friendly angle-iron). Spacing between gate beams will be sufficient to restrict human access to the cave, but not so tight as to impede bat flight through the gate or to result in collisions. The gate will be placed away from the entrance and not in the most constricted parts of the passage.

The following protective measures will be implemented during gate construction to minimize negative effects to bats:

- Gating will be conducted between May 15 and July 31, 2018, when the majority of bats will have moved to summer habitat.
- Since there is the potential for a small number of Indiana bats to use the cave during the period when gating would occur, the area in the vicinity of the planned gate installation will be inspected prior to construction activities to evaluate potential effects to non-migrating Indiana bats.
- If air flow is moving into the cave, an air curtain will be installed each day during construction to prevent exposure of bats roosting inside the cave to construction fumes.
- To prevent the spread of *Pseudogymnoascus destructans*, the current USFWS WNS decontamination protocol will be followed during gate construction.

Qualified biologists will be present during gate installation to provide assistance to the gating contractor and to ensure that protective measures are implemented.

The third cave gating phase will consist of development of a mitigation management plan(s) in collaboration with the USFWS and KDFWR that will include a monitoring and adaptive management plan. Monitoring will be conducted during the first three years of the mitigation project to provide the assurance that the gate was installed correctly and that it will function effectively through its operational life. In addition, Wind Cave will be regularly surveyed by the KDFWR on at least a biennial basis for the foreseeable future. However, if the KDFWR or the USFWS cannot continue their biennial monitoring efforts for any reason, EDPR will provide funding and personnel to continue biennial monitoring for the remainder of the ITP term. In such a case, at least one person with prior knowledge of the cave would be present during the first year of monitoring by EDPR-sponsored personnel.

EDPR will, in coordination with KDFWR, complete annual reports following each year of monitoring to be provided to the USFWS FFO and BFO. The reports will evaluate the effectiveness of the new gate in years 1-3 (i.e., evaluation at the time of installation to determine that bats are not impeded by the gate during their passage into and out of the cave) and in subsequent years the reports will discuss trends in bat populations and any signs of human visitation and make appropriate management recommendations to mitigate any issues discovered. To ensure that any required management actions can be implemented prior to the subsequent hibernation period, the mitigation monitoring report will be submitted annually by June 30.

Winter Habitat Protection Credit

The Applicant used the USFWS Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects, Version 7 (USFWS 2016a) to calculate the Indiana bat credit for the proposed Wind Cave gating project. The following information was received from the Kentucky Department of Fish and Wildlife and the Kentucky Office of the USFWS to inform input parameters for the winter habitat protection module of the REA Model:

- Project start year – 2018

- Project end year – 2055
- N (population size of hibernaculum)- 2015 - 2,878 (down from 3,573 in 2013), MYSE present (1 observed)
- Evidence of WNS resiliency – No
- Evidence of non-disturbance threat - No
- Evidence of disturbance/vandalism - Yes
- Hibernaculum easily accessible- Yes
- Bats in accessible locations - Yes
- Low Ceiling - Yes
- Clumped or clustered - Yes
- Proportion of N in accessible locations - 75% or greater

Based on these inputs to the REA Model, protecting Wind Cave would result in credit for a total of 85 female Indiana bats.

Collectively, female take from the Project and lost reproductive capacity of females represents the annual loss of approximately 18.55 Indiana bats per year over the 27-year ITP. The winter mitigation action, therefore, will provide take coverage for 4.6 years (85 total Indiana bats gained / 18.55 Indiana bats per year taken = 4.6 years) of predicted impact of take for Indiana bats.

CONCLUSION

In summary, the Applicant estimates the following impact of take of the Covered Species and calculates the following mitigation credit, based on current USFWS guidance, for the proposed winter habitat mitigation project for the Headwaters HCP. The remaining impact of take will be offset by additional mitigation project(s) which will be identified and selected according to the criteria and schedule identified in the HCP.

Impact of take:

- 501 Indiana bats
- 88 northern long-eared bats

Mitigation credit:

- Winter habitat protection = 85 Indiana bats

REFERENCES

Kurta, A. 2004. Roosting Ecology and Behavior of Indiana Bats (*Myotis sodalis*) in Summer. Pp. 29-42. *In*: K. C. Vories and A. Harrington, eds. Indiana Bat and Coal Mining: A Technical Interactive Forum. US Department of Interior, Office of Surface Mining, Alton, Illinois Coal Research Center, Southern Illinois University, Carbondale, Illinois. Louisville, Kentucky, Louisville, Kentucky.

US Fish and Wildlife Service (USFWS). 2016a. Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects: Public V1, December 2016. Bloomington, Indiana.

US Fish and Wildlife Service (USFWS). 2016b. Region 3 Northern Long-eared Bat Resource Equivalency Analysis Model for Wind Energy Projects: Public V1, December 2016. Bloomington, Indiana.

Appendix B. Use of the US Geological Survey Evidence of Absence Statistical Framework to Develop Take Predictions for Indiana Bats and Northern Long-Eared Bats

Use of the USGS Evidence of Absence Statistical Framework to Develop Take Predictions for Indiana Bats and Northern Long-Eared Bats

1.0 INTRODUCTION

EDP Renewables has prepared a Habitat Conservation Plans (HCP) in support of an Incidental Take Permit (ITP) application for Indiana bats and northern long-eared bats (Covered Species) for the Headwaters Wind Farm (Project). HCPs include predictions of the numbers of Covered Species that will be taken and specify methods for monitoring and estimating numbers of Covered Species that have been taken to assess permit compliance. The Headwaters HCP used the Evidence of Absence (EoA; Huso et al 2015) approach to fatality estimation to develop a take prediction and monitoring for the HCP will use EoA to determine take compliance. This document describes how EoA was used to predict take (Section 5) and will be used to estimate take during monitoring (Section 4).

'Evidence of Absence' refers to a variety of different concepts. In general, it refers to a Bayesian fatality estimator (Huso et al 2015). It can also refer to a software library for the R statistical computing platform that implements some variants of the EoA estimator (EoA software; Dalthorp et al 2014)[1]. It additionally refers to the Design Tradeoffs module within the EoA software, which determines the outcome of different monitoring design parameters on the probability to detect carcasses during searches, or *g*. Also within the EoA software, 'Evidence of Absence' can refer to the Scenario Explorer module, which investigates likely outcomes of adaptive management regimes during the course of ITP permits via simulation. Finally, outside of the direct application of statistical methodology, 'Evidence of Absence' refers to an adaptive management framework that assumes use of the EoA estimator to track compliance with HCPs (Dalthorp and Huso 2015).

In this document, EoA refers broadly to the Bayesian fatality estimator. Reference to the software, the adaptive management framework, or other modules within the software are explicitly noted as such. The Evidence of Absence framework is rich with notation; Table 1 at the end of this appendix lists all parameters and indices used in this appendix, which models they inform, and how they are obtained.

2.0 EVIDENCE OF ABSENCE OVERVIEW

2.1 Model Form

The EoA estimator takes as inputs the number of carcasses, X, found during searches along with an estimate of the accompanying probability to detect those carcasses, g. From these, it estimates the minimum number of carcasses, *m,* which arrived during the study:

$$Pr(M \geq m \mid X, g) \leq \alpha \tag{1}$$

[1] The citation is the user manual for version 1.0. The EoA software is currently in version 1.06 with version 2.0 in beta testing, but the most recent documentation is for version 1.0.

where

M is the total number of carcasses (Poisson-distributed),
m is the point estimate at the credibility level $1 - \alpha$,
X is the count of carcasses from searches (binomially-distributed),
g is the probability to detect a carcass, given that it occurred (beta-distributed), and
$1 - \alpha$ is the desired credibility for the estimate.

In the use of this model, α is specified in a way appropriate to the situation (i.e., it is driven by policy), X is known exactly from data, g is unknown and estimated as $\hat{g}$, and a prior distribution is specified for M. The estimate of fatality m is obtained by calculating the posterior distribution for M and extracting the $100(1 - \alpha)\%$ upper credible bound (or quantile) from the posterior distribution. When the desired estimate is a fatality rate rather than a total number of fatalities, EoA can estimate the posterior distribution of λ, the underlying fatality rate parameter for the Poisson distribution that generates M. That is,

$$M \sim Poisson(\lambda), \tag{2}$$

and EoA estimates the posterior of λ

$$Pr(\lambda \mid X, g). \tag{3}$$

Variants of the EoA estimator discussed in this document and available through the EoA software differ with respect to estimation of $\hat{g}$ and may differ with respect to the prior distribution assumed for $\widehat{M}$ or $\hat{\lambda}$. Otherwise, the parameters are identical to those in the EoA software.

2.1.1 Prior Distributions

EoA software versions 1.05 through 2.0 (beta), and the analyses presented in this HCP, implement a reference prior distribution for $\widehat{M}$:

$$Pr(M) \propto \int_{m}^{m+1} \frac{1}{\sqrt{m}}\, dm \tag{4}$$

and a Jeffrey's prior distribution for $\hat{\lambda}$:

$$Pr(\lambda) \propto \frac{1}{\sqrt{\lambda}} \tag{5}$$

Dalthorp and Huso (2015) provide the rationale for choice of these priors. The choice of prior distributions for $\widehat{M}$ and $\hat{\lambda}$ are not definitive features of the EoA estimator. The EoA software also implements uniform priors and informed priors (Dalthorp et al 2014, Huso et al 2015). At present, the reference prior for $\widehat{M}$ and the Jeffrey's prior for $\hat{\lambda}$ are thought to be the most robust for general use, but alternatives may be developed in the future.

3.0 MODEL PARAMETERS

3.1 Estimation of *g*: Overall Probability to Observe a Carcass

A key input to the EoA fatality estimator is the probability to detect a carcass, g, given that a carcass has arrived at the wind farm. Like the choice of priors, the method to estimate g is not a definitive feature of EoA (Huso et al 2015). Analyses presented and proposed in this document calculate g following the methods in the EoA software v1.06[2]. The estimate of g is the product of the fraction of turbines searched, γ, the probability that a carcass at a searched turbine falls within a searched area, a, and the probability that a carcass falling in a searched area persists and is detected by a searcher, $\hat{\pi}$. The estimates of $\hat{\pi}$ are derived from several other models: searcher efficiency, the rate at which searcher efficiency changes with subsequent searches, k, carcass persistence, and carcass arrival phenology. Each component of g is described in turn in the following sections.

3.1.1 Probability That a Carcass Falls within a Searched Area (Weighted Distribution Method)

Fatality monitoring protocols may include search plots that are not large enough to capture all carcasses that arrive at turbines. Estimates of g include a component (area correction, a) that accounts for carcasses that may have fallen outside of searched areas (or the probability that a carcass at a searched turbine falls within a searched area), whether search plots were too small to capture all carcasses, or whether plots were irregularly shaped (e.g., road and turbine pad plots).

Carcass fall density is not uniform around turbines; rather, the relative density of carcasses nearer to turbines tends to be greater than the relative density of carcasses far from turbines (Hull and Muir 2010). It is necessary to model the fall distribution of carcasses relative to the turbine mast via distance (hereafter, "distance distribution") so that the fraction of carcasses that occur within searched areas can be estimated. Modelling the fall distribution of carcasses is complicated because the observed fall distribution is influenced by a finite search radius (i.e., the underlying distribution is truncated) and because the observed fall distribution is distorted by unequal detection probability based on carcass distance from turbines. For these reasons, calculating the area correction, a, is complicated.

Area correction, a, is calculated by estimating the proportion of carcasses expected to fall within searched areas:

---

[2] These methods are not formally documented elsewhere but are described here based on a close reading of the EoA software code.

$$a = \sum_{x=1}^{u} H_x \times \sigma_x \quad (6)$$

where a is the area correction factor, x indexes a series of 1-m-wide annuli centered on the turbine, u is the maximum search radius in meters, σ_x is the fraction of the x^{th} annulus searched (calculated in a Geographic Information System), and H_x is the proportion of all carcasses occurring within the x^{th} annulus.

H_x is calculated as

$$Pr(x - 1 < Y < x) = H_x = \int_{x-1}^{x} h(y|\hat{\theta})\, dy \quad (7)$$

where $h(x)$ is the estimated distance distribution of carcasses (from turbine center) and $\hat{\theta}$ are the parameters associated with the distance distribution.

The distance distribution of carcasses (from turbines) is assumed to follow one of six probability distributions (normal, gamma, Weibull, log-logistic, Gompertz, or Rayleigh), and sample-size corrected Akaike's Information Criterion (AICc) is used to select the best model for the available data. The raw observed distances of carcasses from turbines (hereafter, "observed distance distribution") do not represent the true underlying distance distribution because the proportion of searchable area may vary with distance from turbine. Also, the carcass distance data may be aggregated over several search strata with different detection probabilities.

A maximum likelihood estimation approach (MLE) is used to fit a weighted distribution (D. Dalthorp, USGS, pers. comm.) to the data, where the weights reflect relative probabilities of detection to account for the divergence between the observed and underlying distance distributions.

If the underlying distance distribution is described by some probability density function, $h(x|\theta)$, where x is distance from the turbine, θ is the associated parameter vector, and the weights are described by a function, $w(x)$, then the weighted distribution is:

$$h^*(x|\theta) = \frac{w(x) \times h(x|\theta)}{\int_0^{\infty} w(y) \times h(y|\theta) dy} \quad (8)$$

where the $w(x)$ in the numerator accounts for the distortion of the underlying distance distribution, $h(x|\theta)$, that arises due to variable detection probability, and the integral in the denominator ensures that the weighted distribution is still a valid probability function.

Although the parameters, $\hat{\theta}$ are obtained by maximizing the likelihood associated with $h^*(x|\theta)$, the underlying density distribution in Equation (7) is approximated as $h(x|\hat{\theta})$.

By using $h(x|\hat{\theta})$ in (7) the area correction accounts for differential detection probabilities within search areas, as well as carcasses that may have fallen beyond the boundaries of the search area.

The weight function needs to include any factor that influences the probability to detect a carcass. Although some components of the weight function are not individually distance-dependent, they become so when combined with data across several search strata with different search radii. The weight function is difficult to approximate because most of its components need to be estimated. The weight function is approximated as

$$w(x) = \frac{\sum_{z=1}^{n} \pi_z \times \lambda_z \times \sigma_{z,x} \times t_z}{\sum_{z=1}^{n} t_z}, \qquad (9)$$

for distances from $0 \leq x \leq r$ meters, and assigned a value of 0 for all other distances. In Equation (9), n is the number of search strata represented in the sample, π_z is the detection probability for a carcass in stratum z (see section below: *Probability that a carcass falling in a searched area persists and is detected by a searcher*), λ_z is the fatality rate in stratum z, t_z is the number of turbines included in stratum z, and $\sigma_{z,x}$ is the average proportion of area searched in the x^{th} annulus in stratum z. If all of the search strata contributing data to the weighted distribution estimate have the same search radius, the weight function can be simplified to:

$$w(x) = \pi_z \times \sigma_{z,x} \qquad (10)$$

because fatality rates do not vary systematically with search plot size.

3.1.2 Searcher Efficiency

Searcher efficiency is the probability that a searcher will successfully detect a carcass that is present within the search area during a search.

Searcher efficiency p follows a simple binomial model and is estimated from experimental trials as:

$$\hat{p} = \frac{number\ of\ trial\ carcasses\ that\ were\ detected\ by\ searchers}{number\ of\ trial\ carcasses\ that\ were\ available\ to\ searchers} \qquad (11)$$

3.1.3 Change in Searcher Efficiency through Successive Searches

For a given carcass, searcher efficiency is not constant through time, but changes with successive searches. First, carcasses decay and eventually disintegrate as they age. Second, easy-to-see carcasses are more readily detected during earlier searches, meaning that carcasses that remain through subsequent searches tend to be inherently more difficult to see.

If searcher efficiency is assumed constant through time, estimates of detection probability will be biased high, and fatality estimates will be biased low, and the converse also holds. Accurate fatality estimates that make best use of the search data require an understanding of how searcher efficiency changes through time.

The multiplicative parameter k describes changing searcher efficiency through time via:

$$p_{j+1} = p_j \times k \tag{12}$$

where p_j is the searcher efficiency on the j^{th} search.

Estimating k requires that searcher efficiency trial carcasses be deployed and left in place through multiple searches, and generally requires large numbers of trial carcasses to ensure adequate sample size beyond the first search. When data that track trial carcasses through a number of searches are available, searcher efficiency can be calculated for successive searches (p_j, where j is an index for searches) and k can be estimated using Bayesian or frequentist methods.

Data to estimate k often are not available. Huso et al. (*in press*) have analyzed bat searcher efficiency data from numerous studies in North America and suggest that in the absence of data, 0.67 is a reasonable value to use for k for bats. A value of 0.67 means that if searcher efficiency is p for a carcass that has been subjected to no previous searches, it will be $p \times 0.67$ for a carcass that has been available for one search (and missed), $p \times 0.67^2$ for a carcass that has been available for two searches (and missed), and so-on.

3.1.4 Carcass Persistence

Not all carcasses that arrive at the wind farm persist on the landscape long enough to be discovered. Scavengers, agricultural activity, or other forces may remove carcasses before searchers have an opportunity to detect them. The average probability of persistence of a carcass is estimated from an interval-censored survival model (Huso et al 2012). Given a search interval of length I, the Huso et al. (2012) approach estimates the average probability that a carcass arriving $\{0, 1, 2, \ldots, I\}$ days before the search will persist until the search. Assuming carcass persistence times follow a probability distribution $f(d)$ with cumulative probability function $F(d)$, the probability of "survival," or persistence, until day d is $1 - F(d)$. If carcass arrival is uniform in time so that the probability of arrival is constant between 0 and I, the average persistence probability r until the first search after a carcass arrives is:

$$r_{1,1} = \frac{\int_0^I 1 - F(d)\, dd}{I} \tag{13}$$

A minor modification of this formula accommodates carcasses that may be missed on the first search and discovered on a subsequent search (the j^{th} search). The average probability that a carcass which has persisted from the $(j-1)^{th}$ search also persists until the j^{th} search is:

$$r_{1,j} = \frac{\int_{(j-1)\times I}^{j\times I} 1-F(d)\,dd}{\int_{(j-2)\times I}^{(j-1)\times I} 1-F(d)\,dd} \quad (14)$$

where $j \geq 2$.

3.1.5 Carcass Arrival Phenology

The detection probability for any particular carcass depends on when it arrives at the wind farm. This is because carcasses that arrive earlier during the study period have the potential to persist through more searches, and therefore have more opportunities to be discovered than carcasses arriving later in the study period. Assume that there are q searches during the study period that occur on days $\{d_1, d_2, \ldots d_q\}$ and assume there are no carcasses available when the study period begins on day $d_0 = 0$. The time interval $\{d_{i-1}, \ldots, d_i$ is the i^{th} arrival interval, and the proportion of carcasses arriving during the i^{th} arrival interval is c_i, where we ensure that all of the carcasses arrive during an interval by ensuring that,

$$\sum_{i=1}^{q} c_i = 1.0 \quad (15)$$

Equality of all of the c_i implies the same relative arrival rate of carcasses between each search interval (i.e., over the entire study period). This would be the case if, for example, the arrival phenology of carcasses is uniform in time and the search interval is constant between searches. The c_i can be adjusted to reflect non-constant arrival phenology, non-constant search interval, or both.

When carcass arrival is pulsed (as it may be if there is a seasonal migration), it is likely that the relative abundance of carcasses during a pulse forms a bell-shaped curve, but it is rare to have appropriate data to estimate the shape of the curve. Even with adequate carcass arrival data, large year-to-year variation in phenology precludes the assumption that one year's estimate will be adequate to predict for a subsequent year.

Consequently, arrival phenology is assumed to be uniform through the intervals within a season and adjustments to the c_i are made on the basis of relative fatality rates from season to season. If seasonal and annual fatality estimates are not available for the target species, fatality estimates for a larger group of species (e.g., all bats) may be used as a surrogate.

3.1.6 Probability That a Carcass Falls in a Searched Area Persists and is Detected by a Searcher

The probability that a carcass arrived during the i^{th} interval persists and is detected on the i^{th} or subsequent searches (*interval-specific detection probability*) is calculated recursively for each search from i to q, where q is the last search. The probability that a carcass persists and is detected on the first search after arrival is:

$$\pi_{i,i} = r_{i,i} \times p \tag{16}$$

where $r_{i,i}$ is the probability of persistence (Equation 14) and p is the probability of detection (Equation 11). The probability that the carcass persists and is detected on the second or subsequent searches after arrival is:

$$\pi_{i,j} = \pi_{i,i} + \sum_{\psi=i+1}^{j} \left(1 - \pi_{i,\psi-1}\right) \times \left(r_{i,\psi} \times p \times k^{\psi-i}\right) \tag{17}$$

where $\pi_{i,j}$ is the probability that a carcass arriving during the i^{th} interval persists and is detected during the j^{th} search and k is the factor by which searcher efficiency changes from one search to the next.

For a study with a total of q search intervals, $\pi_{i,j}$ can be calculated for any $0 \leq i \leq j \leq q$, but in practice we are interested in the probability that a carcass arriving during the i^{th} interval is detected at *some* point before the end of the study, i.e. $\pi_{i,q}$.

The first element of the product in the summand of Equation (17) represents the probability that the carcass is missed during all previous searches and the second element of the product in the summand of Equation (17) represents the probability that the carcass is discovered during the j^{th} search.

The overall probability of detection for a carcass is the average of the interval-specific arrival probabilities weighted by the arrival fraction c_i:

$$\pi = \sum_{i=1}^{q} \pi_{i,q} \times c_i. \tag{18}$$

3.1.7 Overall Probability of Carcass Detection

For a wind farm with z search strata having T_z turbines in each of the z strata, of which t_z are searched, the overall probability that a carcass arriving at the wind farm will fall in a searched area, remain available for searchers, and be detected is:

$$g = \sum_{i=1}^{z} \frac{t_i}{T_i} \times a_i \times \pi_i \tag{19}$$

The variance of this estimator is unknown. Bootstrap resampling procedures are used to approximate confidence intervals for this estimator when required.

4.0 FATALITY ESTIMATION

Fatality estimation in EoA is straightforward: carcass counts and probabilities of detection are analyzed using EoA, and a take estimate M is obtained with the desired level of credibility.

4.1 Single-Site, Single-Year Fatality Estimation

The EoA software provides functionality to calculate a fatality estimate for a single site during a single year. The estimating model is exactly as given in Section 2.1.1 – *Model Form*. This module of the EoA software is the only module that calculates g based on user-supplied information about the arrival function, search schedule, probability that a carcass falls in a searched area, searcher efficiency, and carcass persistence. The form of the information accepted by the software varies by version; Versions 2.0 (beta) and higher return g as the two parameters that describe a beta distribution, while earlier versions return g with 95% confidence intervals, calculated in Section 3.1.7 – *Overall Probability of Carcass Detection.*

The EoA software takes the probability of carcass detection, g, and the count of carcasses from searches, X, as inputs and returns the posterior distribution of total fatality. Versions 2.0 and later also return the posterior distribution of the fatality rate, λ.

4.2 Multiple Year (or Multiple Season) Fatality Estimation

When data are available from multiple search periods (years or seasons), the EoA software can provide a cumulative estimate of fatality that covers the entire search history. The estimating model is exactly as given in Section 2.1.1 – *Model Form*. Inputs to the EoA software are in the form of a matrix with one row for each search period.

For versions 1.06 and earlier, the columns contain carcass counts, the point estimate of g, upper and lower 95% confidence bounds for g, and annual weights. For versions 2.0 and later, the columns contain carcass counts, the two parameters of a beta distribution that describe g, and annual weights. The annual weights are proportional to the expected relative fatality rates for each sampling period.

Although fatality rates are unknown, weights may vary with wind farm size (if, for example, a wind farm doubles in size between two sample periods) or with adaptive management actions (e.g., a wind farm implements an adaptive management action that is expected to reduce fatality by half). The weights are used to calculate a weighted average g:

$$g = \frac{\sum_{b=1}^{sampling\ periods} g_b \times v_b}{\sum_{b=1}^{sampling\ periods} v_b} \qquad (20)$$

where g_b and v_b are the sampling-period-specific probabilities of detection and weights, respectively.

The multiple year module of the EoA software returns an estimate of total cumulative fatality, M, or an estimate of the average fatality rate, λ. If λ is returned, it carries units of carcasses per wind farm per sampling period and it is scaled to be relative to a wind farm operating with a weight of 1.0.

4.3 Multiple Site (or Search Stratum) Fatality Estimation

When data are available from multiple sites or multiple search strata within a site, the EoA software can provide a cumulative estimate of fatality covering the entire searched area. The estimating model is exactly as given in Section 2.1.1 – *Model Form*. Inputs to the EoA software are in the form of a matrix with one row for each stratum.

For versions 1.06 and earlier, the columns contain carcass counts, the point estimate of π, upper and lower 95% confidence bounds for π, and stratum weights. For versions 2.0 and later, the columns contain carcass counts, the two parameters of a beta distribution that describe π, and stratum weights.

The stratum weights are the fraction of carcasses that are expected to fall within each search stratum (i.e., a from Section 3.1.6 – *Probability That a Carcass Falls in a Searched Area Persists and is Detected by a Searcher*). In version 2.0 and later, the stratum weights must sum to 1.0 and the input matrix always includes an unsearched stratum (with $\pi = 0$) to account for unsearched turbines or areas.

The weights are used to calculate a weighted average g:

$$g = \sum_{z=1}^{sampling\ strata} \pi_z \times a_z \tag{21}$$

where π_z and a_z are the stratum-specific probabilities of detection and area corrections, respectively.

The multiple site module of the EoA software will return an estimate of total fatality, M, or an estimate of the fatality rate, λ. If λ is returned it carries units of carcasses per sampling period and it covers the entire area represented within the input data table.

4.4 Selecting Credible Bounds from Evidence of Absence Estimates

Because EoA is a Bayesian model, the estimates it returns are distributions of total take, or the take rate. When a single number is needed to set a threshold or determine compliance, it is necessary to select a credible bound from the posterior distribution. There is no objective way to select credible bounds; the decision is based on a subjective assessment of the risks of setting the wrong threshold that would result in being in noncompliance with an incidental take permit (ITP). In general, the 50th credible bound, or median of the distribution, is a good value to use for a point estimate: in this case, there is 50% confidence that the true value is not greater than that estimated value. As larger credible bounds are chosen, confidence increases that the true value will not be larger than the estimated value.

5.0 FATALITY PREDICTION

It is often desirable to obtain fatality predictions based on past fatality estimates but unless a fatality prediction is desired for the same time interval and the same area that informed the prediction, it is not possible to use the estimate of M in fatality prediction. The estimate of M is specific to the duration, area, and operational regime (i.e., turbine cut-in speed) where data were collected. Similarly, an estimate of M that is calculated for a wind farm with two equally-sized phases cannot be rescaled to represent one phase of the wind farm. This is because M is a credible bound from a Poisson posterior, and the quantiles of Poisson distributions do not scale in a linear way.

When a fatality prediction is needed, the procedure is to estimate the fatality rate, λ, for a wind farm that is sufficiently comparable to the wind farm for which a prediction is desired. Unlike M, the credible bounds of λ can be rescaled to represent larger or smaller facilities, or longer or shorter time periods, or facilities with different operational regimes. For example, if λ is estimated (at a desired level of credibility: Q_λ) for a wind farm with 100 turbines over a 2-year period and a prediction is needed for a 200-turbine wind farm for 30 years, the predicted fatality rate (with the same Q_λ) will be $\lambda_{pred} = 2 \times 15 \times \lambda$.

Getting from λ_{pred} to a predicted number of fatalities for the purpose of developing a take prediction to set a take authorization number for an ITP requires the selection of a credible bound (Q_M) for the prediction of M. The predicted number of fatalities is then the Q_M credible bound (= Q_M quantile) from a Poisson distribution with a rate parameter equal to λ_{pred}.

6.0 MONITORING DESIGN

The EoA software has a *Design tradeoffs* module that is useful when designing fatality monitoring. The module calculates g as described in Section 3.1 – *Estimation of g: Overall Probability to Observe a Carcass* given user input and returns the results in graphical format.

Table 1. Parameters and indices used in this appendix, which models they inform, and how they are obtained.

Parameter	Definition	How Obtained	Models in Which it is Used
α	One minus the credibility of an estimate	Subjective decision	
$\boldsymbol{a}$	area correction- the proportion of carcasses expected to fall within searched areas	Estimated	Overall probability of detection
$\boldsymbol{b}$	Index for sampling periods within a multiple-year or multiple-season EoA estimate	Index	Evidence of Absence

c_i	Fraction of carcasses arriving during the i^{th} interval	Assumed uniform within seasons; Estimated among seasons	Overall probability of detection
d	Time (days) to carcass removal	Function input	Carcass persistence
$f(d)$	Probability distribution function for persistence times (d; days) of carcasses	Estimated	Carcass persistence
$F(d)$	Cumulative distribution function for persistence times (d; days) of carcasses	Estimated	Carcass persistence
g	Overall probability that a carcass arriving at the wind farm persists and is detected by searchers	Estimated	Overall probability of detection
$g_{i,j}$	Probability that a carcass arriving during the i^{th} interval persists until and is discovered during the j^{th} interval, conditional on having persisted until the $j-1^{th}$ interval	Estimated	Overall probability of detection
γ	Proportion of turbines searched	Known	Overall probability of detection
H_x	Proportion of carcasses in the annulus that covers between $x-1$ and x meters from turbines	Estimated	Area correction
$h(x\|\theta)$	Probability distribution function for distances (x; meters) of carcasses from turbines	Estimated	Distance distribution
$h^*(x\|\theta)$	Weighted probability distribution function for distances (x; meters) of carcasses from turbines	Estimated	Distance distribution
I	Duration of search interval; number of days between searches	Known	Carcass persistence
i	Index for intervals	Index	Carcass persistence, overall probability of detection
j	Index for searches	Index	Carcass persistence, overall probability of detection
k	Factor by which searcher efficiency (p) changes between searches	Assumed ($k = 0.67$) or estimated	Overall probability of detection
λ	Fatality rate	Estimated	Model form
M	Total fatality	Estimated	Model form

n	Number of search strata contributing data to the distance distribution ($h^*(x \mid \theta)$) of carcasses from turbines	Known	Distance distribution of carcasses
p	Searcher efficiency; this is the probability that a carcass that is in a search area during a search is detected by a searcher	Estimated	Overall probability of detection
Pr	Abbreviation for *Probability*	Abbreviation	
π	Probability that a carcass within a searched area will be available to searchers and detected	Estimated	Overall probability of detection
Q	Credible bound for estimation or prediction of λ or M	Subjectively selected	Fatality estimation
q	Number of searches and search intervals during the study	Known from field data	Overall probability of detection
$r_{i,j}$	Average probability that a carcass arriving during interval i persists until search j	Estimated	Carcass persistence, overall probability of detection
s	Index for carcasses informing the distance distribution	Index	Distance distribution
S	Total number of carcasses informing the distance distribution	Known from field data	Distance distribution
σ_x	Average proportion of area searched between $x-1$ meters and x meters from the turbine	Estimated in GIS	Distance distribution
$\sigma_{z,x}$	Average proportion of area searched between $x-1$ meters and x meters from the turbine in stratum z	Estimated in GIS	Distance distribution
T_z	Total number of turbines in sampling stratum z	Known from field data	Distance distribution
t_z	Number of turbines sampled within a sampling stratum z	Known from field data	Distance distribution
θ	Parameters associated with the probability distribution function for distances of carcasses from turbines $h(x \mid \theta)$	Estimated	Distance distribution
$\hat{\theta}$	Estimated parameters associated with the weighted probability distribution function for distances of carcasses from turbines $h^*(x \mid \theta)$	Estimated	Distance distribution
u	Maximum search distance (meters)	Known from field data	Distance distribution

v	Sampling period weights for a multiple-year or multiple-season EoA estimate	Estimated	Searcher efficiency, overall probability of detection
$w(x)$	Weighting function (of distance, x; meters) used to fit the weighted distance distribution of carcasses from turbines ($h^*(x \mid \theta)$)	Estimated	Distance distribution
X	Count of carcasses from monitoring searches	Known from data	Model form
x	Distance (meters) of carcasses from turbines	Function input	Distance distribution
z	Index for search strata	Index	Distance distribution, overall probability of detection

7.0 LITERATURE CITED

Dalthorp, D. and M. Huso. 2015. A framework for decision points to trigger adaptive management actions in long-term incidental take permits: U.S. Geological Survey Open-File Report 2015-1227, 88 pp. http://dx.doi.org/10.3133/ofr20151227.

Dalthorp, D., M. Huso, D. Dail, and J. Kenyon. 2014. Evidence of absence software user guide: U.S. Geological Survey Data Series 881, 34 pp. http://dx.doi.org/10.3133/ds881

Hull, C.L. and S. Muir. 2010. Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Australasian Journal of Environmental Management 17:77-87

Huso M, N. Som, and L. Ladd. 2012. Fatality estimator user's guide. USGS Data Series 729.

Huso, M.M.P., D. Dalthorp, D. Dail, and L. Madsen. 2015. Estimating wind-turbine-caused bird and bat fatality when zero carcasses are observed. Ecological Applications, 25: 1213–1225. doi:10.1890/14-0764.1

Huso, M., D. Dalthorp, and F. Korner-Nievergelt. In Press. Statistical Principles of Post-Construction Fatality Monitoring Design. In Perrow, M. (ed) *Wildlife and Wind Farms, Conflicts and Solutions, Volume 2, Onshore: Monitoring and Mitigation*. Exeter: Pelagic Publishing.

Appendix C. Project Location and References for the 50 Publicly Available Mortality Monitoring Studies in the Eastern and Midwestern United States and Canada Reporting the Sex of Bat Carcasses Found

Appendix C. Project Location and References for the 50 Publicly Available Mortality Monitoring Studies in the Eastern and Midwestern United States and Canada Reporting the Sex of Bat Carcasses Found

Appendix C. Project location and references for the 50 publicly available mortality monitoring studies in the eastern and Midwestern United States and Canada reporting the sex of bat carcasses found.

Project	Reference
Barton I and II	Derby et al. 2011b
Blue Sky Green Field	Gruver et al. 2009
Buffalo Mountain (2000-2003)	Nicholson et al. 2005
Buffalo Mountain (2005)	Fiedler et al. 2007
Buffalo Ridge (2000)	Krenz and McMillan 2000
Buffalo Ridge (Phase II; 2001/Lake Benton I)	Johnson et al. 2004
Buffalo Ridge (Phase III; 2001/Lake Benton II)	Johnson et al. 2004
Buffalo Ridge I (2010)	Derby et al. 2010d
Buffalo Ridge II (2011)	Derby et al. 2012a
Casselman (2008)	Arnett et al. 2009
Casselman (2009)	Arnett et al. 2010
Cohocton/Dutch Hill (2009)	Stantec 2010
Cohocton/Dutch Hills (2010)	Stantec 2011
Criterion (2011)	Young et al. 2012b
Crystal Lake II	Derby et al. 2010b
Elm Creek	Derby et al. 2010e
Elm Creek II	Derby et al. 2012b
Fowler I, II, III (2010)	Good et al. 2011
Fowler I, II, III (2011)	Good et al. 2012
Grand Ridge I	Derby et al. 2010a
Lakefield Wind	Minnesota Public Utilities Commission (MPUC) 2012
Lempster (2009)	Tidhar et al. 2010
Lempster (2010)	Tidhar et al. 2011
Locust Ridge II (2009)	Arnett et al. 2011
Locust Ridge II (2010)	Arnett et al. 2011
Mars Hill (2008)	Stantec 2009a
Moraine II	Derby et al. 2010f
Mount Storm (Fall 2008)	Young et al. 2009b
Mount Storm (2009)	Young et al. 2009a, 2010b
Mount Storm (2010)	Young et al. 2010a, 2011b
Mount Storm (2011)	Young et al. 2011a, 2012a
Munnsville (2008)	Stantec 2009b
Noble Bliss (2009)	Jain et al. 2010c
Noble Clinton (2009)	Jain et al. 2010a
Noble Ellenburg (2009)	Jain et al. 2010b
NPPD Ainsworth	Derby et al. 2007
Pioneer Prairie I (Phase II)	Chodachek et al. 2012
Prairie Winds ND1 (Minot)	Derby et al. 2011d
Prairie Winds ND1 (Minot) (2011)	Derby et al. 2012d
Prairie Winds SD1 (Crow Lake)	Derby et al. 2012c
Prince Wind Farm (2006)	Natural Resource Solutions Inc. (NRSI) 2008
Rugby	Derby et al. 2011c
Sheldon (2010)	Tidhar et al. 2012a
Sheldon (2011)	Tidhar et al. 2012b
Stetson Mountain I (2011)	Normandeau Associates 2011
Stetson Mountain II (2010)	Normandeau Associates 2010
Wessington Springs (2009)	Derby et al. 2010c
Wessington Springs (2010)	Derby et al. 2011a
Winnebago	Derby et al. 2010g
Wolfe Island Report 2 (July-December 2009)	Stantec Ltd. 2010

LITERATURE CITED

Arnett, E. B., M. R. Schirmacher, M. M. P. Huso, and J. P. Hayes. 2009. Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities: 2008 Annual Report. Prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. Bat Conservation International (BCI), Austin, Texas. April 2009. http://www.batsandwind.org/pdf/Curtailment_2008_Final_Report.pdf

Arnett, E. B., M. R. Schirmacher, M. M. P. Huso, and J. P. Hayes. 2010. Patterns of Bat Fatality at the Casselman Wind Project in South-Central Pennsylvania. 2009 Annual Report. Annual report prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. Bat Conservation International (BCI), Austin, Texas. January 2010.

Arnett, E. B., M. R. Schirmacher, C. D. Hein, and M. M. P. Huso. 2011. Patterns of Bird and Bat Fatality at the Locust Ridge II Wind Project, Pennsylvania. 2009-2010 Final Report. Prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission (PGC). Prepared by Bat Conservation International (BCI), Austin, Texas. January 2011.

Chodachek, K., C. Derby, M. Sonnenberg, and T. Thorn. 2012. Post-Construction Fatality Surveys for the Pioneer Prairie Wind Farm I LLC Phase II, Mitchell County, Iowa: April 4, 2011 – March 31, 2012. Prepared for EDP Renewables, North America LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 27, 2012.

Derby, C., A. Dahl, W. Erickson, K. Bay, and J. Hoban. 2007. Post-Construction Monitoring Report for Avian and Bat Mortality at the NPPD Ainsworth Wind Farm. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, for the Nebraska Public Power District.

Derby, C., J. Ritzert, and K. Bay. 2010a. Bird and Bat Fatality Study, Grand Ridge Wind Resource Area, Lasalle County, Illinois. January 2009 - January 2010. Prepared for Grand Ridge Energy LLC, Chicago, Illinois. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. July 13, 2010. Revised January 2011.

Derby, C., K. Chodachek, and K. Bay. 2010b. Post-Construction Bat and Bird Fatality Study Crystal Lake II Wind Energy Center, Hancock and Winnebago Counties, Iowa. Final Report: April 2009-October 2009. Prepared for NextEra Energy Resources, Juno Beach, Florida. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. June 2, 2010.

Derby, C., A. Dahl, A. Merrill, and K. Bay. 2010c. 2009 Post-Construction Monitoring Results for the Wessington Springs Wind-Energy Facility, South Dakota. Final Report. Prepared for Wessington Wind Energy Center, LLC, Juno Beach, Florida. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 19, 2010.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010d. Post-Construction Fatality Survey for the Buffalo Ridge I Wind Project. May 2009 - May 2010. Prepared for Iberdrola Renewables, Inc., Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010e. Post-Construction Fatality Surveys for the Elm Creek Wind Project: March 2009- February 2010. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010f. Post-Construction Fatality Surveys for the Moraine II Wind Project: March - December 2009. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010g. Post-Construction Fatality Surveys for the Winnebago Wind Project: March 2009- February 2010. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., A. Dahl, K. Bay, and L. McManus. 2011a. 2010 Post-Construction Monitoring Results for the Wessington Springs Wind Energy Facility, South Dakota. Final Report: March 9 – November 16, 2010. Prepared for Wessington Wind Energy Center, LLC, Juno Beach, Florida. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. November 22, 2011.

Derby, C., K. Chodachek, K. Bay, and S. Nomani. 2011b. Post-Construction Fatality Surveys for the Barton I and II Wind Project: IRI. March 2010 - February 2011. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. Version: September 28, 2011.

Derby, C., K. Chodachek, K. Bay, and S. Nomani. 2011c. Post-Construction Fatality Surveys for the Rugby Wind Project: Iberdrola Renewables, Inc. March 2010 - March 2011. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. Version: October 14, 2011.

Derby, C., K. Chodachek, T. Thorn, K. Bay, and S. Nomani. 2011d. Post-Construction Fatality Surveys for the PrairieWinds ND1 Wind Facility, Basin Electric Power Cooperative, March - November 2010. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 2, 2011.

Derby, C., K. Chodachek, and M. Sonnenberg. 2012a. Post-Construction Casualty Surveys for the Buffalo Ridge II Wind Project. Iberdrola Renewables: March 2011- February 2012. Prepared for Iberdrola Renewables, LLC, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 31, 2012.

Derby, C., K. Chodachek, and M. Sonnenberg. 2012b. Post-Construction Fatality Surveys for the Elm Creek II Wind Project. Iberdrola Renewables: March 2011-February 2012. Prepared for Iberdrola Renewables, LLC, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. October 8, 2012.

Derby, C., A. Dahl, and A. Merrill. 2012c. Post-Construction Monitoring Results for the PrairieWinds SD1 Wind Energy Facility, South Dakota. Final Report: March 2011 - February 2012. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. September 27, 2012.

Derby, C., K. Chodachek, T. Thorn, and A. Merrill. 2012d. Post-Construction Surveys for the PrairieWinds ND1 (2011) Wind Facility Basin Electric Power Cooperative: March - October 2011. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western Ecosystems Technology, Inc. (WEST), Bismarck, North Dakota. August 31, 2012.

Fiedler, J. K., T. H. Henry, R. D. Tankersley, and C. P. Nicholson. 2007. Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005. Tennessee Valley Authority. June 28, 2007.

Good, R. E., W. P. Erickson, A. Merrill, S. Simon, K. Murray, K. Bay, and C. Fritchman. 2011. Bat Monitoring Studies at the Fowler Ridge Wind Energy Facility, Benton County, Indiana: April 13 - October 15, 2010. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. January 28, 2011.

Good, R. E., A. Merrill, S. Simon, K. Murray, and K. Bay. 2012. Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: April 1 - October 31, 2011. Prepared for the Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 31, 2012.

Gruver, J., M. Sonnenberg, K. Bay, and W. Erickson. 2009. Post-Construction Bat and Bird Fatality Study at the Blue Sky Green Field Wind Energy Center, Fond Du Lac County, Wisconsin July 21 - October 31, 2008 and March 15 - June 4, 2009. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. December 17, 2009.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and K. Russell. 2010a. Annual Report for the Noble Clinton Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. March 9, 2010.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and K. Russell. 2010b. Annual Report for the Noble Ellenburg Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. March 14, 2010.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, A. Fuerst, and A. Harte. 2010c. Annual Report for the Noble Bliss Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. March 9, 2010.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat Activity, Composition and Collision Mortality at a Large Wind Plant in Minnesota. Wildlife Society Bulletin 32(4): 1278-1288.

Krenz, J. D. and B. R. McMillan. 2000. Final Report: Wind-Turbine Related Bat Mortality in Southwestern Minnesota. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Minnesota Public Utilities Commission (MPUC). 2012. Lakefield Wind Project Avian and Bat Fatality Monitoring. MPUC Site Permit Quarterly Report and USFWS Special Purpose – Utility (Avian Take Monitoring) 30-Day Report: April 1 – September 30, 2012. USFWS Permit No: MB70161A-0; MDNR Permit No: 17930; MPUC Permit No: IP-6829/WS-09-1239, Permit Special Condition VII.B. October 15, 2012.

Natural Resource Solutions Inc. (NRSI). 2008. Fall 2006 Bird and Bat Mortality Monitoring, Prince Wind Power Project. Project No. 647 Prepared for Brookfield Renewable Power, Gatineau, Quebec. Prepared by NSRI. February 2008.

Nicholson, C. P., J. R.D. Tankersley, J. K. Fiedler, and N. S. Nicholas. 2005. Assessment and Prediction of Bird and Bat Mortality at Wind Energy Facilities in the Southeastern United States. Final Report. Tennessee Valley Authority, Knoxville, Tennessee.

Normandeau Associates, Inc. 2010. Stetson Mountain II Wind Project Year 1 Post-Construction Avian and Bat Mortality Monitoring Study, T8 R4 Nbpp, Maine. Prepared for First Wind, LLC, Portland, Maine. Prepared by Normandeau Associates, Inc., Falmouth, Maine. December 2, 2010.

Normandeau Associates, Inc. 2011. Year 3 Post- Construction Avian and Bat Casualty Monitoring at the Stetson I Wind Farm, T8 R4 Nbpp, Maine. Prepared for First Wind Energy, LLC, Portland, Maine. Prepared by Normandeau Associates, Inc., Falmouth, Maine. December 2011.

Stantec Consulting, Inc. (Stantec). 2009a. Post-Construction Monitoring at the Mars Hill Wind Farm, Maine - Year 2, 2008. Prepared for First Wind Management, LLC, Portland, Maine. Prepared by Stantec Consulting, Topsham, Maine. January 2009.

Stantec Consulting, Inc. (Stantec). 2009b. Post-Construction Monitoring at the Munnsville Wind Farm, New York: 2008. Prepared for E.ON Climate and Renewables, Austin, Texas. Prepared by Stantec Consulting, Topsham, Maine. January 2009.

Stantec Consulting, Inc. (Stantec). 2010. Cohocton and Dutch Hill Wind Farms Year 1 Post-Construction Monitoring Report, 2009, for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. January 2010.

Stantec Consulting, Inc. (Stantec). 2011. Cohocton and Dutch Hill Wind Farms Year 2 Post-Construction Monitoring Report, 2010, for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC, and Canandaigua Power Partners II, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. October 2011.

Stantec Consulting Ltd. (Stantec Ltd.). 2010. Wolfe Island Ecopower Centre Post-Construction Followup Plan. Bird and Bat Resources Monitoring Report No. 2: July - December 2009. File No. 160960494. Prepared for TransAlta Corporation's wholly owned subsidiary, Canadian Renewable Energy Corporation. Prepared by Stantec Ltd., Guelph, Ontario. May 2010.

Tidhar, D., W. Tidhar, and M. Sonnenberg. 2010. Post-Construction Fatality Surveys for Lempster Wind Project, Iberdrola Renewables. Prepared for Lempster Wind, LLC, Lempster Wind Technical Advisory Committee, and Iberdrola Renewables, Inc. Prepared by Western EcoSystems Technology Inc. (WEST), Waterbury, Vermont. September 30, 2010.

Tidhar, D., W. L. Tidhar, L. McManus, and Z. Courage. 2011. 2010 Post-Construction Fatality Surveys for the Lempster Wind Project, Lempster, New Hampshire. Prepared for Iberdrola Renewables, Inc. and the Lempster Wind Technical Committee. Prepared by Western EcoSystems Technology, Inc., Waterbury, Vermont. May 18, 2011.

Tidhar, D., L. McManus, Z. Courage, and W. L. Tidhar. 2012a. 2010 Post-Construction Fatality Monitoring Study and Bat Acoustic Study for the High Sheldon Wind Farm, Wyoming County, New York. Final Report: April 15 - November 15, 2010. Prepared for High Sheldon Wind Farm, Sheldon Energy LLC, Chicago, Illinois. Prepared by Western EcoSystems Technology, Inc. (WEST), Waterbury, Vermont. April 15, 2012.

Tidhar, D., L. McManus, D. Solick, Z. Courage, and K. Bay. 2012b. 2011 Post-Construction Fatality Monitoring Study and Bat Acoustic Study for the High Sheldon Wind Farm, Wyoming County, New York. Final Report: April 15 - November 15, 2011. Prepared for High Sheldon Wind Farm, Sheldon Energy LLC, Chicago, Illinois. Prepared by Western EcoSystems Technology, Inc. (WEST), Waterbury, Vermont. April 25, 2012.

Young, D.P., Jr., K. Bay, S. Nomani, and W. Tidhar. 2009a. Nedpower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: March - June 2009. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. August 17, 2009.

Young, D.P., Jr., W. P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009b. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring, July - October 2008. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. February 17, 2009.

Young, D.P., Jr., K. Bay, S. Nomani, and W. Tidhar. 2010a. Nedpower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: April - July 2010. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. August 27, 2010.

Young, D.P., Jr., K. Bay, S. Nomani, and W. Tidhar. 2010b. Nedpower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: July - October 2009. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. February 12, 2010.

Young, D.P., Jr., S. Nomani, Z. Courage, and K. Bay. 2011a. Nedpower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: April - July 2011. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. August 29, 2011.

Young, D.P., Jr., S. Nomani, W. Tidhar, and K. Bay. 2011b. Nedpower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: July - October 2010. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. February 10, 2011.

Young, D.P., Jr., S. Nomani, Z. Courage, and K. Bay. 2012a. Nedpower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: July - October 2011. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. February 27, 2012.

Young, D.P., Jr., M. Lout, Z. Courage, S. Nomani, and K. Bay. 2012b. 2011 Post-Construction Monitoring Study, Criterion Wind Project, Garrett County, Maryland: April - November 2011. Prepared for Criterion Power Partners, LLC, Oakland, Maryland. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Waterbury, Vermont. April 20, 2012. Revised November 25, 2013.

Appendix D. Mitigation Fund and Ledger for the Headwaters Wind Farm Habitat Conservation Plan

NATURAL RESOURCES ● SCIENTIFIC SOLUTIONS
408 W. 6th Street, Bloomington, IN 47404
Phone: 812-339-1756 ● www.west-inc.com

TECHNICAL MEMORANDUM

Date: November 2, 2016, revised July 27, 2017

To: Scott Pruitt, Marissa Reed, U.S. Fish and Wildlife Service, Bloomington Field Office

From: Quintana Hayden and Cara Meinke, Western EcoSystems Technology, Inc. and Erin O'Shea and Christina Calabrese, EDP Renewables, North America

Subject: Mitigation Banking-Style Option for the Headwaters Wind Farm Habitat Conservation Plan

BACKGROUND

The memo that follows describes a proposed approach to the structure and function of a mitigation "bank" style option for EDP Renewable's (EDPR) Headwaters Habitat Conservation Plan (HCP). EDPR is not proposing that a formal mitigation bank be established, rather that the concept be used to facilitate using a mitigation property to fulfill mitigation for more than one HCP. The purpose of establishing this option would be to allow EDPR to store surplus credit from the mitigation projects secured for the Headwaters HCP and enable that surplus credit to be withdrawn to offset the impact of take under other EDPR HCPs currently in development in U.S. Fish and Wildlife Service (USFWS) Region 3. Surplus credit refers to the number of Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*) (Covered Species) credits produced by the mitigation projects beyond the number of bats needed to offset the impact of take under the Headwaters HCP. The mitigation projects include winter habitat protection through gating of Wind Cave in Kentucky, and protection of swarming and summer habitat through conservation of a yet-to-be-identified property.

MITIGATION BANK OPTION

Under the mitigation bank-style option, EDPR proposes to establish an amount of mitigation credit conferred by the Headwaters HCP mitigation projects for each of the Covered Species in a stand-alone document to be agreed upon by EDPR and the USFWS. The document could be attached to the Headwaters HCP and any other relevant HCPs (e.g., the in-development HCP for EDPR's Meadow Lakes project) as an appendix for public review.

The mitigation credit document would be accompanied by a ledger for tracking the amount of credit used by each EDPR HCP in the Headwaters HCP project file (and other HCPs, as appropriate). This ledger would be a living document that would be updated every fifth year of each HCP's Incidental Take Permit. The updated ledger would accompany that year's monitoring report to the USFWS.

WEST Inc.

NATURAL RESOURCES ● SCIENTIFIC SOLUTIONS
408 W. 6th Street, Bloomington, IN 47404
Phone: 812-339-1756 ● www.west-inc.com

Although the mitigation projects described in the mitigation credit document will be secured by EDPR in their entirety, the credit necessary to offset the impact of taking for the Headwaters HCP and other EDPR HCP(s) would be withdrawn just prior to the five-year period for which it is needed. At the end of each five-year period, the amount of mitigation credit withdrawn for that period will be compared to the actual impact of take estimated from the monitoring data collected during the same five-year period and any surplus mitigation credit would be deposited back into the bank. Conversely, if the amount of mitigation credit withdrawn for the period was less than the actual impact of take, the deficit of mitigation credit would be added to the amount of credit withdrawn for the next five-year period[1]. In either case, the mitigation would remain ahead of the taking because EDPR will secure the initial mitigation upfront or no later than two years after receiving the Incidental Take Permit and the ledger is simply a process by which to track how much of the mitigation credit has been assigned to offset the impact of take over time. If additional mitigation projects are secured in the future, their associated mitigation credit may be added to the ledger.

An example of this process, using hypothetical numbers, is shown below. In the example, the initial predicted impact of take for HCP A is 2 Indiana bats and 1 northern long-eared bat per year. The initial predicted impact of take for HCP B, which is approved two years after HCP A, is 4 Indiana bats and 2 northern long-eared bats per year. Both HCPs are found to have a surplus of mitigation credit after the first five-year period, which EDPR considers a likely scenario for their HCPs due to the conservative take prediction approach used in these HCPs. The example only shows the first 15 years of HCP A, to demonstrate the process; the next entry in this ledger would be the withdrawal of the Period 3 credit for HCP B (unless a third HCP was added prior to that event, or HCP B again has a surplus to deposit from Period 2 before making the Period 3 withdrawal).

Hypothetical Example Demonstrating the Ledger Process

Year	Action	Amount		Total Mitigation Credit in "Bank"	
		INBA	NLEB	INBA	NLEB
2017	Bank Established	+ 850	+ 250	850	250
2017	Withdrawal – HCP A, Period 1	- 10	- 5	840	245
2019	Withdrawal – HCP B, Period 1	- 20	- 10	820	235
2022	Deposit – HCP A, Period 1 (surplus)	+ 2	+ 1	822	236
2022	Withdrawal – HCP A, Period 2	- 8	- 4	814	232
2024	Deposit – HCP B, Period 2 (surplus)	+ 9	+4	823	236
2024	Withdrawal – HCP B, Period 2	- 11	- 6	812	230
2027	Withdrawal – HCP A, Period 3	- 8	- 4	804	226

INBA = Indiana bat, NLEB = Northern long-eared bat

[1] It is very likely that this event would be accompanied by an adaptive management action, due to the higher-than-expected actual take. The estimated take, and consequently the amount of mitigation credit necessary, for the next five-year period after the adaptive management action would be calculated as described in the HCP's adaptive management plan.

NATURAL RESOURCES ● SCIENTIFIC SOLUTIONS
408 W. 6th Street, Bloomington, IN 47404
Phone: 812-339-1756 ● www.west-inc.com

EDPR MITIGATION LEDGER

Year	Action	Amount		Total Mitigation Credit in Fund	
		INBA	NLEB	INBA	NLEB
2017	Mitigation Fund Established	+ 85	+ tbd*	85	tbd*

INBA = Indiana bat, NLEB = Northern long-eared bat
*Pending identification of a summer habitat mitigation property

Appendix E. Wind Cave Gating Management Plan for the Headwaters Habitat Conservation Plan

Wind Cave Gating Management Plan
Wayne County, Kentucky

Prepared for:

EDP Renewables, North America

808 Travis Street, Suite 700
Houston, Texas 77002

Prepared by:

T. Travis Brown, Rhett Good, and Cara Meinke

Western EcoSystems Technology, Inc.
408 West 6th Street Bloomington, Indiana 47404

September 30, 2016

WEST Inc.

EXECUTIVE SUMMARY

EDP Renewables (EDPR) has requested assistance from Western Ecosystems Technology, Inc. (WEST) in pursuing mitigation options to support the Headwaters Wind Farm (HWF) Habitat Conservation Plan (HCP) for federally endangered Indiana bats (INBA) and federally threatened northern long-eared bats (NLEB). This document describes the importance and location of a cave gating project, as well as pre-construction monitoring conducted to-date and proposed studies and monitoring to be conducted in the future.

Wind Cave is a Priority 2 INBA hibernaculum in Wayne County, Kentucky, and is considered to be the highest priority for gating in Kentucky due to human disturbance of hibernating bats. In addition to INBA and NLEB, little brown bat, tri-colored bat, eastern small-footed bat, big brown bat, and Rafinesque's big-eared bat have been observed to use the cave during harp trapping and winter hibernaculum counts. While up to 60 NLEB have been observed in the cave in the past, recent acoustic surveys failed to identify high levels of NLEB activity near the cave during fall swarming.

The proposed gate location is at a slight constriction inside the cave where bedrock, dry conditions, and lack of soil provide appropriate conditions for gate construction. The passage at this location is roughly oval in shape, and is a maximum of 5.3 meters (m; 17.3 feet [ft]) high by 12.3 m (40.3 ft) wide.

WEST conducted flight path monitoring during the fall of 2015 using thermal infrared and night vision equipment. Bat flight behavior at the proposed gate location consisted primarily of direct flights through the top 50% of the passage. Circular flights, consistent with swarming behavior, occurred closer to the cave entrance, and the proposed gate location appears to provide an appropriate location to place the gate.

In the fall of 2016, we propose to begin documenting pre-gating temperature and humidity in Wind Cave by placing two climate loggers in areas where INBA hibernate. Loggers will record data over the winter season, and will be retrieved in the spring of 2017.

After gate installation, the gate will be monitored for potential negative effects to bats, including effects on egress/ingress and swarming behavior, and on the temperature and humidity within the cave. In addition, the gate will be monitored annually to determine whether it continues to function effectively.

STUDY PARTICIPANTS

Western EcoSystems Technology, Inc.

Cara Meinke	Project Manager
Rhett Good	Senior Manager
Travis Brown	Field Supervisor
Ben Hale	Bat Biologist
Kevin Murray	Acoustic Expert
Aaron McAlexander	Bat Biologist
Rebecca Schmitt	Technical Editor
Andrea Palochak	Technical Editor

REPORT REFERENCE

Brown, T.T., R. Good, and C. Meinke. 2016. Wind Cave Gate Management Plan, Wayne County, Kentucky. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana.

ACKNOWLEDGEMENTS

We thank Erin O'Shea (EDP Renewables) for funding, Mike Armstrong (USFWS Kentucky Field Office) and Scott Pruitt (USFWS Indiana Field Office) for providing an opportunity to complete the project (as well as providing valuable input concerning logistics and methodology), Brooke Hines (formerly KDFWR) for early logistical support, and Lonzo Dishman for permission to conduct the studies on his property.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

EDP Renewables (EDPR) has requested assistance from Western Ecosystems Technology, Inc. (WEST) in pursuing mitigation options in support of the Headwaters Wind Farm (HWF) Habitat Conservation Plan (HCP) for federally endangered Indiana bats (INBA, *Myotis sodalis*) and federally threatened northern long-eared bats (NLEB, *M. septentrionalis*). This document describes a proposed strategy for one potential mitigation project, the gating of Wind Cave in Wayne County, Kentucky.

INBAs are known to migrate from hibernacula in Kentucky to summer habitat as far north as Michigan (Kurta 2008); therefore, the protection of winter habitat in Kentucky will benefit INBA that establish maternity colonies in Indiana near the HWF, or that migrate through the HWF. Due to the fact that INBA and NLEB populations are currently being decimated by white-nose syndrome (WNS), protection of hibernacula from additional sources of stress is important. Wind Cave is considered by the USFWS (USFWS) Frankfort Field Office (FFO) and the Kentucky Department of Fish and Wildlife Resources (KDFWR) to be the highest priority cave left to be gated in Kentucky due to evidence of human disturbance to hibernating bats. The gating of Wind Cave represents an important conservation opportunity for both of these federally-listed species.

Wind Cave is a Priority 2 INBA hibernaculum. In 2015, the cave was home to 2,878 INBA (down from 3,537 observed in 2013; M. Armstrong, USFWS Kentucky Field Office [KFO], pers. comm.). As many as 60 NLEBs were observed in the cave in 2013, and one NLEB was observed in 2015. Other bat species known to use the cave include the little brown bat (*M. lucifugus*), tri-colored bat (*Perimyotis subflavus*), eastern small-footed bat (*M. leibii*), big brown bat (*Eptesicus fuscus*), and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*; M. Armstrong, pers. comm.).

The cave location is well-known to the public, the entrance is located near a road, and the landowner has noted use of the cave by trespassers. Use by humans during the swarming and hibernation periods creates disturbance to INBA since greater than 75% of hibernating population of INBA in the cave are clustered in low ceiling areas that are vulnerable to disturbance and/or predation. Therefore, the cave gating project will minimize the potential for federally-listed bats to be negatively affected by potential vandalism in the future, providing an important conservation benefit.

PROPOSED GATING LOCATION

The proposed gate location is approximately 35 meters (m, 115 feet [ft]) inside the entrance to Wind Cave. This area is relatively dry, and the bedrock found here provides an appropriate surface for mounting the gate. While the passage does constrict somewhat in this area, allowing a practicable location to install the gate, this location is not the most constricted portion of the cave passage. Two separate cave gate installers have identified this location as the appropriate area to build a gate (M. Armstrong, USFWS, pers. comm.). The passage in this area is shaped as an irregular oval, with a maximum ceiling height of approximately 5.3 m (17.3 ft) and a maximum width of roughly 12.3 m (40.3 ft; Figures 1, 2, and 3).

Figure 1. Photograph of the proposed Wind Cave gate location.

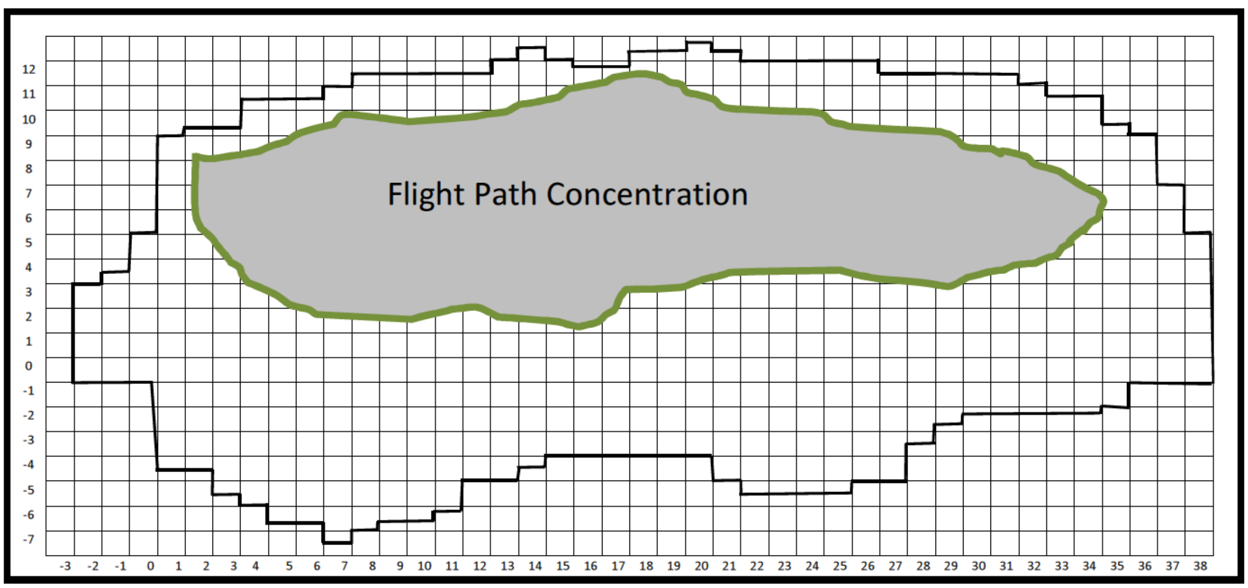

Figure 2. Area of use by exiting bats as observed by night vision active monitoring on September 29 and October 12, 2015 (grid cell size is 30 square centimeters [cm^2; 0.98 square feet (ft^2)]).

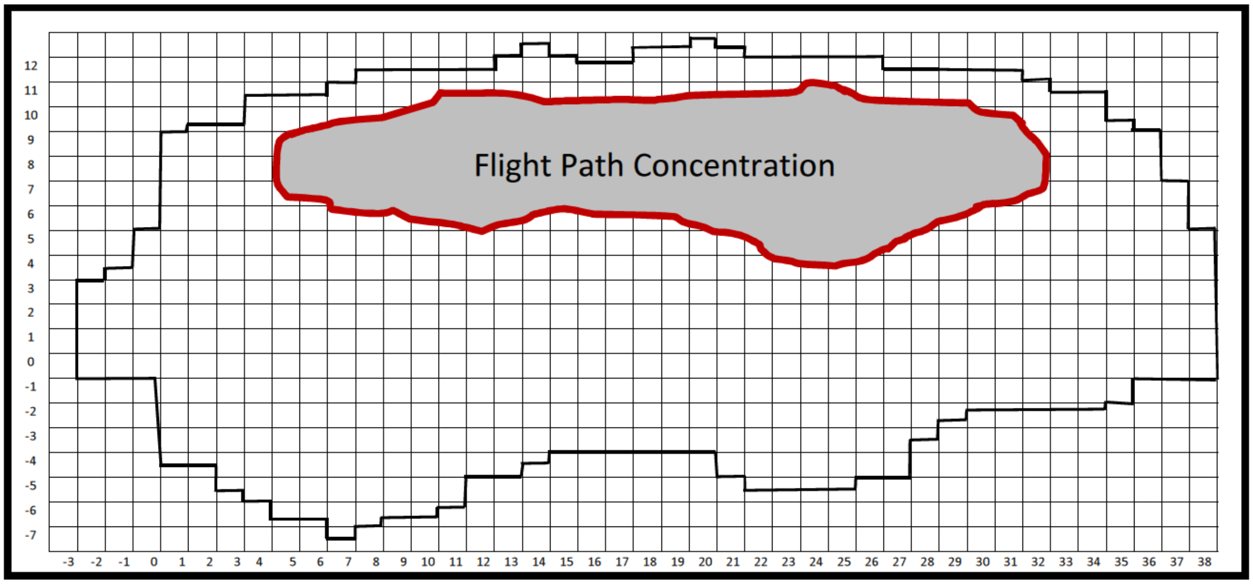

Figure 3. Area of use by exiting bats as observed by passive infrared thermal recording on September 29 and October 12, 2015 (grid cell size is 30 square centimeters [cm^2; 0.98 square feet (ft^2)]).

SUMMARY OF SURVEYS COMPLETED

Harp Trapping

A preliminary harp trapping survey was conducted at the entrance of Wind Cave on April 14, 2015 by KDFWR bat biologist B. Hines and two WEST biologists. The purpose of trapping was to gather additional information regarding use by NLEB. Trapping yielded three INBA, one little brown bat, one eastern small-footed bat, and one tri-colored bat before the survey was discontinued due to low temperatures and rain.

Acoustic Monitoring

WEST conducted acoustic monitoring at Wind Cave during the fall of 2015 in order to determine the level of NLEB activity near the cave (Brown et al. 2016). The ultimate objective of acoustic monitoring was to assess the utility of conducting an intensive spring harp trapping effort, which might be used to estimate the population of NLEB using Wind Cave. NLEB are not readily counted during winter hibernaculum surveys due to their habit of hibernating singly and in small crevices or cracks (USFWS 2014), and up to 60 NLEB had been observed in the cave in the past; therefore, high levels of NLEB acoustic activity would have been considered to be justification for spring harp trapping.

Acoustic activity of NLEB was very low in the vicinity of Wind Cave. During 51 detector nights, only three call files from NLEB were identified by automated software. Of these, only one file was confirmed as NLEB during qualitative review of the data. Brown et al. (2016) determined that it was unlikely that substantial numbers of NLEB currently occur in the cave; therefore, it was considered unlikely that the substantial effort and expense necessary to estimate NLEB abundance in the cave (harp trapping for three nights per week for three weeks in the spring) was justified.

Flight Path Monitoring

WEST biologists conducted flight path monitoring at Wind Cave during the fall of 2015 in order to determine the likelihood of bat collisions or disruption of bat flight paths as a result of gate installation (Brown et al. 2016). Prior to monitoring, a cross-section drawing of the gate location was created, and two qualified bat biologists federally-permitted to survey for INBA and NLEB monitored the proposed gate location using Generation 3 night vision goggles (AN/PVS-7 Military Issue Goggle System, Optics HQ [no longer in business]) and outdoor thermal infrared (IR) network AXIS Q1910-E cameras (AXIS Communications, Sweden, Lund) for two nights of appropriate weather. Monitoring occurred for two hours each night after bats had begun flying from the entrance. Flight concentration polygons from field monitoring and thermal camera recordings were digitized and combined to produce minimum convex polygons representing locations where the majority of bats fly through the proposed gate location. Numbers of bats and their behaviors were also summarized using both observation methods.

Flight paths of exiting bats were concentrated in the top 50% of the proposed gate location using both night vision and IR technologies (Figures 2 and 3). More bats were observed and counted using IR recording equipment at a greater range compared to the use of night vision goggles. Using night vision goggles, the total emergence count on September 29, 2015, was 139 bats, and the total utilizing IR technology was 1,196 exiting bats. On October 12, 2015, the total emergence count was 136 bats using night vision goggles, and 115 bats using IR technology.

The majority of bat flights observed with both methods consisted of straight flight paths. On rare occasions, bats were observed flying in large arcs throughout the proposed gate area to the cave opening. These behaviors were relatively rare (less than 20 bats among the 1,311 bats that emerged) and were not representative of behavior observed in the gate area. Within two hours on both survey nights, bats that were observed to re-enter the cave did so via straight flight paths. On both survey nights, within two hours, bats were observed to re-enter the cave via straight flight paths.

Circular flights, consistent with swarming behavior, occurred closer to the cave entrance, particularly in an open area leading to a small passage directly to the left of the cave entrance (after entering the cave). This location is approximately 30 m (98 ft) from the proposed gate location and is closely associated with bats entering and exiting the cave entrance. The proposed gate location appears to provide an appropriate location to place the gate. This location is less likely to cause collisions than a gate located closer to the cave entrance, where more erratic flight paths occur during fall swarming.

PROPOSED STUDIES

In the fall of 2016, we propose to begin documenting pre-gating temperature and humidity in Wind Cave by placing two climate loggers (HOBO U23 v2 Temperature/Relative Humidity Data Loggers or similar) in areas where INBA hibernate. Loggers will record data over the winter season, and will be retrieved in the spring of 2017.

PROPOSED MONITORING

Post-Construction Monitoring

The entrance of the cave will be monitored with thermal infrared camera equipment during the fall migration/swarming period of 2017 to monitor whether or not the newly installed gate is affecting egress/ingress and/or swarming behavior. Cameras will be placed in the cave and will record bat behavior for approximately two hours after bat activity is first observed. The cave entrance will be monitored for four nights during this critical period. The gate will be monitored concurrently by at least one federally-permitted bat biologist with night vision equipment. During monitoring, the timing, frequency, and duration of abnormal flight behaviors during egress and ingress (e.g., bats landing on the cave gate or crawling, rather than flying, through the gate) will be recorded. In addition, all potential predators and any observed predation events will be recorded.

Two climate loggers (HOBO U23 v2 Temperature/Relative Humidity Data Loggers or similar) will be placed in areas where INBA hibernate to monitor post-construction climate conditions for two years following construction. Speloggers or similar equipment will be installed within the Wind Cave entrance, and will be checked bi-annually to monitor human use. Data from speloggers will be downloaded, batteries will be changed, and general observations of conditions at the cave entrance will be recorded. Digital photographs will be taken of the cave entrance and gate to provide an annual record of damage, graffiti, trash, and signs of WNS (e.g., dead bats or bat bones) at the cave entrance. Monitoring will be conducted during the first three years of the mitigation project to provide the assurance that the gate was installed correctly and that it will function effectively through its operational life. In addition, Wind Cave will be regularly surveyed by the KDFWR on at least a biennial basis for the foreseeable future. However, if the KDFWR or the USFWS cannot continue monitoring their biennial monitoring efforts for any reason, EDPR will provide funding and personnel to continue monitoring efforts for the remainder of the Incidental Take Permit term. In such a case, at least one person with prior knowledge of the cave would be present during the first year of monitoring by EDPR-sponsored personnel.

WEST, in cooperation with the KDFWR and EDPR, will complete annual reports during the three-year monitoring period of the mitigation project, and the reports will be provided to the USFWS FFO and BFO. The reports will evaluate the effectiveness of the new gate in Year 1 (i.e., evaluation at the time of installation to determine that bats are not impeded by the gate during their passage into and out of the cave) and in subsequent years. The reports will discuss trends in microclimate data and make appropriate management recommendations to mitigate any issues discovered. To ensure that any required management actions can be implemented prior to the subsequent hibernation period, the mitigation monitoring report will be submitted annually by June 30.

REFERENCES

Brown, T. T., B. Hale, and K. Murray. 2016. Pre-Construction Gate Location Monitoring at Wind Cave, Wayne County, Kentucky. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana.

Kurta, A. 2008. Bats of Michigan. Indiana State University Center for North American Bat Research and Conservation. Publication Number 2.

US Fish and Wildlife Service (USFWS). 2014. Northern Long-Eared Bat Interim Conference and Planning Guidance. USFWS Regions 2, 3, 4, 5, and 6. January 6, 2014. Available online at: http://www.fws.gov/northeast/virginiafield/pdf/NLEBinterimGuidance6Jan2014.pdf